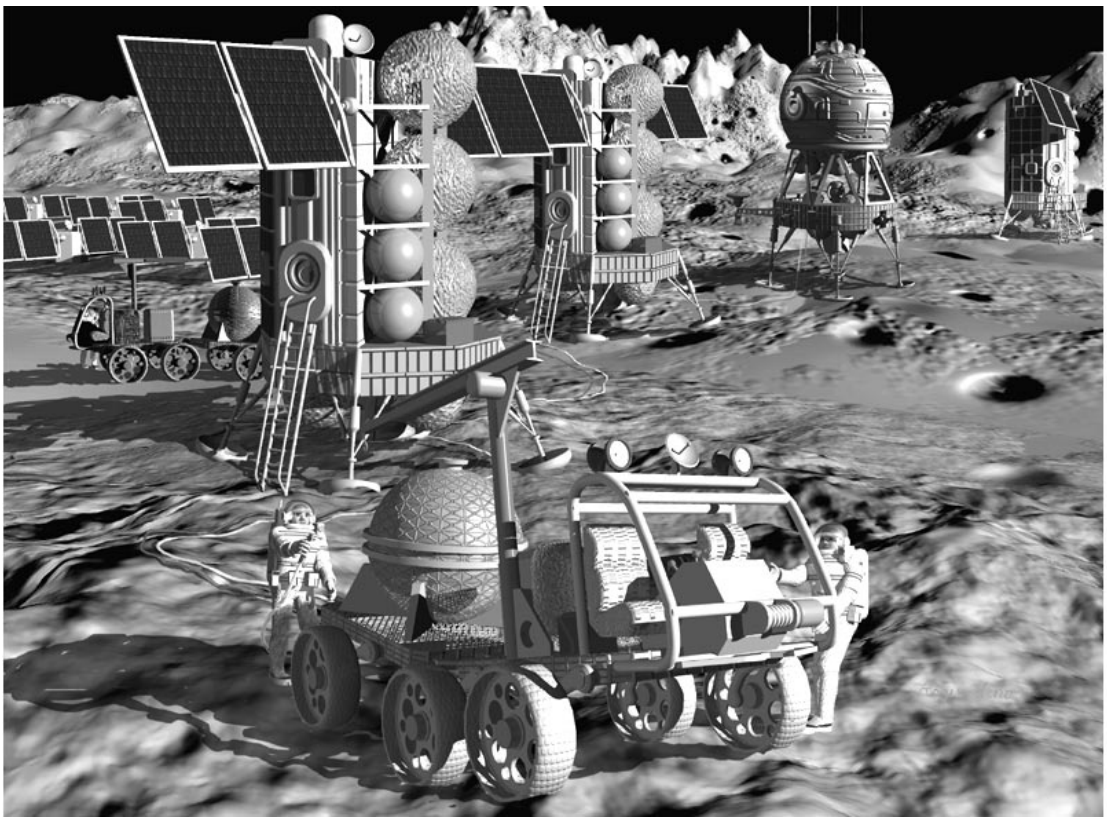
NASA/TM–1999-112240

Director's Discretionary Fund Report for Fiscal Year 1998

Ames Research Center



March 1999

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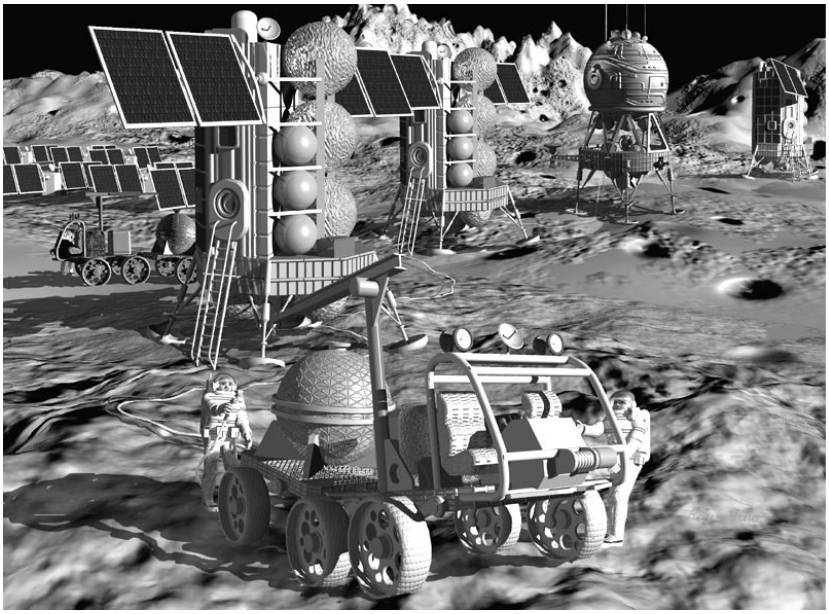
Director's Discretionary Fund Report for Fiscal Year 1998

Ames Research Center, Moffett Field, California



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Contents

Introduction

The Director's Discretionary Fund (DDF) at Ames Research Center was established to fund innovative, high-risk projects in basic research that are essential to our future programs but otherwise would be difficult to initiate. Summaries of individual projects within this program are compiled and issued by Ames each year as a NASA Technical Memorandum.

These summaries cover 16 final and 25 ongoing projects in Fiscal Year 1998.

The contents are listed alphabetically according to the last name of the primary investigator in two sections (final and ongoing reports). Following the narrative reports, two appendixes (for final and ongoing reports) contain brief descriptions with the financial distribution and status of each of the projects.

Any questions can be addressed to an investigator directly.

Section 1
Final Reports

Solid-State Oxygen Microsensor for Atmospheric-Entry Applications

Investigator(s)

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K. R. Sridhar, Ames IPT from University of Arizona, 933 N. Cherry Ave., Tucson, AZ 85721

Objectives of the study

To establish the feasibility of using the microsensor in aerothermal applications by demonstrating its survivability on the surface of a heat shield during simulated atmospheric flight. A 20-megawatt electric-arc heated plasma facility at Ames was used. After completing this objective successfully, four additional objectives were pursued, including fabricating and calibrating amperometric oxygen sensors operating in the range 10 to 760 torr total pressure, characterizing the oxygen content of arc-jet streams using laser-induced-fluorescence techniques, measuring oxygen pressures on test bodies in arc-heated facilities, and determining if the microsensor can discriminate atomic versus molecular oxygen. The first three of these objectives were accomplished during this period of research. Work on the remaining two has begun, but is not reported here. Experiments were conducted in the Ames Aerodynamic Heating Facility (AHF), arc jet, at the Space Technologies Lab at the University of Arizona, and in the laser lab in Building N234 at Ames.

Progress and results

The first three of the five objectives were met. This research has demonstrated the viability of measuring oxygen partial pressure on the surface of spacecraft for planetary entry applications using this technology. Experiments showed successful integration into a silicone-impregnated reusable ceramic ablator (SIRCA) heat shield and survivability in four arc-jet tests. Microsensors operating over the range of oxygen pressure from microbars to one atmosphere were produced and calibrated in two laboratory test stands, one at Ames and one at the University of Arizona.

Sensor description

Microsensors using solid-oxide electrolysis of oxygen ions have been adapted to the severe environment characteristic of planetary atmospheric entry of spacecraft. Oxygen-bearing gases are pumped, or ionically conducted, at elevated temperatures through an yttria-stabilized zirconia electrolyte (fig. 1). Normal operating temperatures are 400 to 1200 degrees C. Through thermal dissociation and electrocatalysis, oxygen ions are driven through the electrolyte in the presence of a bias potential. The total current indicates the oxygen flux through the electrolyte, thus is the primary output of the sensor. The oxygen-bearing gas must first diffuse through porous platinum electrodes deposited on the ceramic surface. By controlling the fabrication process for the porous electrolyte, the rate of diffusion through the pores is controlled. By creating oxygen diffusion as the overall rate-limiting process, the range of sensitivity of the microsensor can be varied from microbars to atmospheric pressure.

Sensor fabrication and calibration

A calibration testbed was built to characterize the microsensors in the range of pressures of interest for aerothermal applications, about 10 torr to one atmosphere. Known mixtures of oxygen-bearing gases are passed through a chamber pumped by a vacuum pump (fig. 2). The sensor in the chamber is heated via an integral platinum heater that is vapor-deposited on the back of the ceramic substrate of the microsensor. Gas flow rates, chamber total pressure, and sensor current output and temperature are recorded using standard analog-to-digital data logging equipment. Results from two sensors tested at 500 degrees C with 700 mV bias potential exposed to a 1-percent oxygen mixture over a varying total pressure are shown in figure 2. Slight variation is seen between the two sensors; however, excellent repeatability was revealed. More experimentation on electrolyte curing during manufacture is needed for optimization to a specific application.

Arc-jet testing

Arc-jet tests were performed to verify attachment methods and thermal survivability of the microsensors on the surface of a planetary spacecraft heat shield in a representative aerothermal flow environment. Four tests with eight sensors successfully demonstrated the survivability and integration techniques for the microsensors on a SIRCA ablative heat-shield material. The feasibility of planetary applications has been demonstrated.

Tests in the 20-megawatt AHF arc-jet facility verified attachment schemes and sensor survival under simulated atmospheric entry conditions. Surface conditions at the

sensor mounted near the stagnation region of a 6-inch-diameter blunt body were: total enthalpy 28 MJ/kg, stagnation pressure up to 10 torr, surface heat flux up to 55 W/cm^2, and exposure duration up to 500 seconds. These tests were piggybacked with ongoing Mars 2001 Orbiter aerobrake heat-shield development. Attachment to a base of SIRCA was via the sensor's platinum lead wires from the sensor's edges through ceramic tubes with ceramic paste and SIRCA adhesive. Temperature data indicated some interaction between hot pyrolysis gases from the ablating heat shield and the platinum RTD heater strip on the back of the microsensors. Figures 3 and 4 show the sensors before and after testing.

Laboratory arc-jet tests will be conducted at the University of Arizona pending completion of the assembly of a small-scale arc-jet chamber.

Arc-jet flow characterization

Independent characterization of the chemical content and thermodynamic state of the arc-jet flow stream was investigated using a two-photon laser-induced florescence (LIF) diagnostic technique. Though not conducted concurrent with the sensor tests, an understanding of the high degree of repeatability of test conditions has been gained by these results. Future work will incorporate simultaneous measurements of oxygen in the arc-jet stream using LIF and the microsensor. The LIF technique produces spatially resolved measurements of centerline flow properties including velocity, temperature, and species concentration of [N] and [O] atoms. The data allow one to determine the enthalpy of the stream broken down into all of its modal components. Chemical and kinetic energy dominate the enthalpy distribution of the plasma stream, with [N] contributions consistently twice that of [O]. Almost no [O2] or [NO] molecules are expected. Results in figures 5 and 6 show centerline temperature and absolute [O] number density measured in the 20-MW AHF arc jet over a range of facility operating conditions. It appears that not all [O] atoms were detected, and that some might exist in metastable states to which the excitation laser was not tuned.

Significance of the results

The instrument can provide data critical to the understanding and characterizing of the chemical composition at the outer surface of a vehicle in a high-enthalpy hypervelocity flow field and the interactions occurring in that region. The instrument offers high sensitivity, low power, mass, and high-temperature ceramic construction. These features make it a unique and potentially beneficial flight instrument for obtaining such previously unknown data. The feasibility of measuring oxygen pressure on a heat-shield surface during planetary entry has been established by this research. The data will aid spacecraft designers by providing data to evaluate thermal protection system performance, thereby enabling reduction in heat-shield mass. This will directly enhance the mass of science payload. The microsensor will provide data to verify numerical prediction of aerothermal flow environments, previously unobtainable. In addition to a flight instrument, it can aid in characterizing the oxygen content of high-enthalpy arc-jet facility flows. It provides a small, surface-mounted instrument by which surface pressure can be measured in wind tunnel facilities.

Keywords

High-enthalpy flow fields, Oxygen microsensor, LIF flow-field characterization

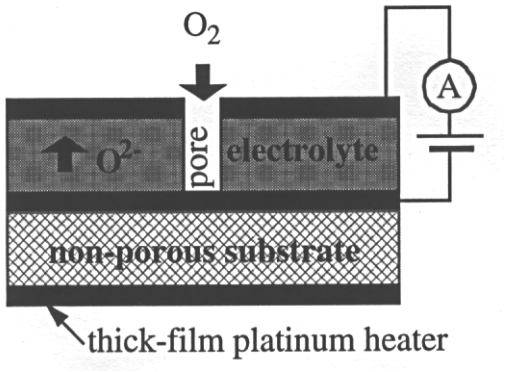

Figure 1. Principle of operation for amperometric oxygen microsensor.

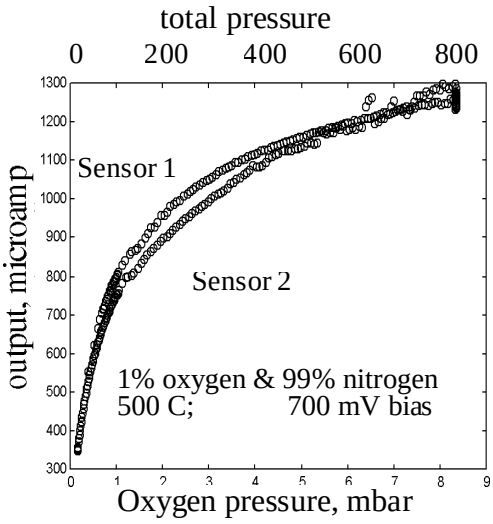

Figure 2. Calibration of microsensors to 1 atm.

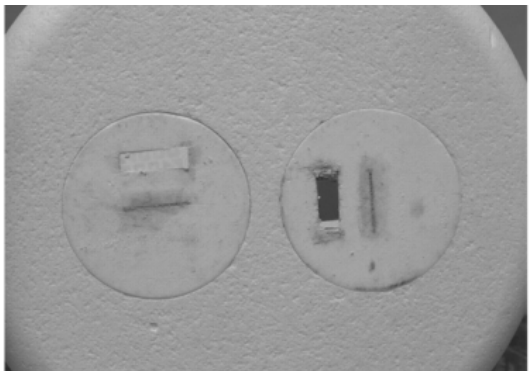

Figure 3. Two microsensors before arc-jet testing.

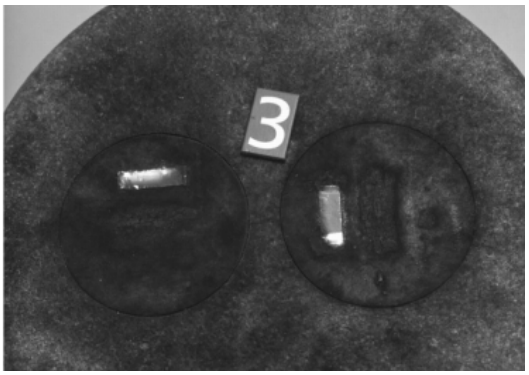

Figure 4. The sensors after 500-second exposure.

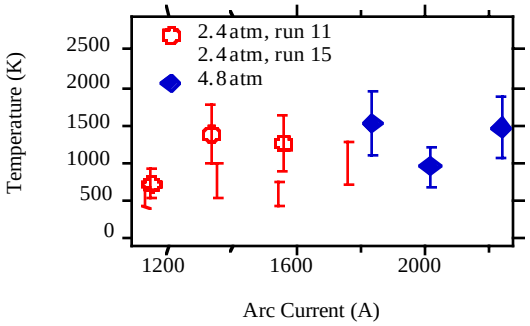

Figure 5. Free-stream temperature in AHF.

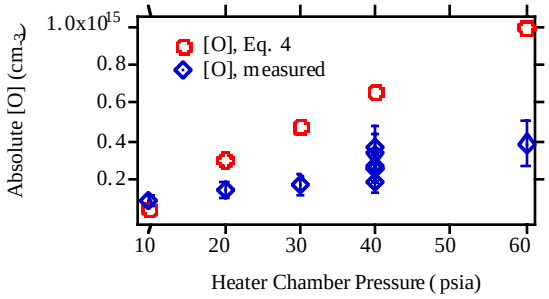

Figure 6. Oxygen number density in AHF free stream.

Visual Servocontrol Applied to Mobile Robot Navigation

Investigator(s)
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Objectives of the study
To develop a visual approach to short-range and terminal mobile robot navigation. Visual servocontrol techniques for mobile robots will be developed; these techniques will be implemented on board under realistic computing and telemetry constraints; and this approach will be demonstrated in realistic outdoor field experiments.

Progress and results
In the first year of the study, the visual servoing testbed was simply strapped to the Marsokhod rover to run outdoor testing. This year, the testbed system was fully integrated into the rover system during a complete overhaul of the electronics of the rover. The dual Pentium computer system of the testbed became the main control computer for the entire rover.

The image processing, visual tracking, and robot control software has been completely redesigned in C++ to take advantage of the object-oriented paradigms of encapsulation and inheritance. A system was created that can easily be reconfigured to control different rovers, different video digitizers, and different camera/pan-tilt systems and to swap in and out of different correlation and tracking algorithms. The system can now be ported to multiple rover platforms without having to regenerate large amounts of code. The system has been successfully ported by CMU to its Nomad rover architecture and will be used to aid in searching for meteorites in Antarctica this winter.

There are three dominant failure modes of visual servocontrol: 1) target loss due to robot motion and subsequent appearance change, 2) above-threshold correlation for an erroneous target (false positive), and 3) correlation that slowly drifts off the target because of a weak feature texture. Modes 1 and 3 were addressed to some extent in the first year of work. Target loss due to robot motion was reduced using a neural network that predicted the target shift in the input image based on rover motion sensor information. The drifting target problem was addressed using a hierarchical correlation scheme that allowed the vision system to utilize the highest resolution available without excessively loading the computer.

Target loss due to its appearance change as the rover approaches is addressed using a visual flow technique that has not yet been tested. In this technique, multiple targets within the input image are tracked to create a visual flow field. This flow field is analyzed to determine how quickly the target appearance is changing. This information is used to determine how quickly to update the target kernel, compensating for more and more rapid changes as the rover nears the target object.

This same technique can be used to mitigate the second failure mode, above-threshold correlation for an erroneous target. Since the system is tracking multiple targets, it can determine whether one target experiences an abrupt motion that is out-of-line with the behavior of the other targets and disregard that input to the control system for the remainder of the tracking sequence. This technique will be fully tested during the upcoming Marsokhod field test in the Mojave Desert, currently scheduled for February 1999.

Significance of the results
The ability of rovers to reach a wide variety of samples and perform analyses on each one is crucial to the success of the surface exploration objectives of the Mars Surveyor program. Traditional techniques for spacecraft navigation are unsuitable for roving vehicles, and worse, they make the vehicle more complex, heavier, and more vulnerable to failure. Visually servoed navigation provides an innovative navigational alternative, consuming little power and telemetry and making use of imaging hardware already baselined for proposed rover missions. Results prove the feasibility of such a system using the limited computational power of the types of processors that will fly on the near-term missions. The visual servoing technique will drastically reduce the ground-control needs for rover missions, with a subsequent reduction in mission costs and an increase in science return.

Keywords
Visual servoing, Computer vision, Robot navigation, Planetary rovers

Life under a Simulated Martian Atmosphere: Past, Present, and Future

Investigator(s)

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Other personnel involved

Hilary F. Waites, summer student: Dept. Biological Sciences, Stanford University, Stanford, CA 94305-5020

Objectives of the study

Understanding the environmental extremities that life is capable of tolerating is both critical to evaluating extra-terrestrial surfaces as abodes for life and fundamental to NASA's Exobiology, Origins, and Astrobiology programs. Low atmospheric pressure and high levels of carbon dioxide (CO_2) are two aspects of the Martian atmosphere most detrimental to the survival of life. The overall objective was to develop a methodology to determine the threshold of pressure and CO_2 at which various life forms can survive as two separate and also as two combined parameters. To provide a facility for doing this, an important objective was to adapt an existing pressure system at Ames to allow for the precise simulation of planetary atmospheric pressures from 10^{-9} to 1 bar with different gas mixtures and to develop appropriate methodologies for measuring gas uptake/exchange with different organisms. The work is important because the Martian surface shows abundant water-eroded features that indicate that the CO_2 partial pressure (and consequent greenhouse effect) must have been much higher three to four billion years ago when microbial life may have existed there. If life did exist on Mars, it would have been slowly subjected to increasing environmental stress as the atmosphere thinned over geological time. As well as determining the parameters that define the survival of life on Mars, the objective was also to consider other predicaments where high CO_2 and/or pressure may have affected life. Such predicaments include the levels of atmospheric pressure and CO_2 that would be required in a Mars closed-loop greenhouse ecosystem (comprising plants and insect pollinators) to sustain life in future human exploration strategies. Also included are the effects on early Earth biota of possible higher levels of CO_2 in the Precambrian, which may have been analogous to early Mars.

Progress and results

Much progress was made in configuring the gas control and analysis system. A computerized gas mixing system using multiple flow controllers was configured to allow the blending of three components to simulate mixtures of nitrogen (or air), CO_2, and a significant trace component (2–5000 ppm) such as methane or CO. The latter was included because it may be representative of early Earth/Mars conditions and offers the possibility to evaluate the possible effect on organism metabolism. The facility thus allows a broad range of adjustable possible atmospheres. The pressure chamber has a glass door to allow observations of some organisms or light for photosynthesis. For the latter, a solar lamp with defined spectral characteristics was implemented.

To allow continuous monitoring of the gas exchange metabolism of organisms, particularly autotrophic species, a computerized gas chromatographic (GC) system was implemented. For oxygenic photosynthetic bacteria, evolution of oxygen provides an effective measure of net metabolism. To get the necessary capability to measure a challenging range of gas concentrations from 95 percent CO_2 to less than 1 ppm of oxygen over a range of different total pressures, the system was defined and trial protocols with various possible gas mixtures were evaluated. The system uses a thermal conductivity detection system to monitor the high percentage concentration of gases and a pulse-discharge helium ionization detector to measure down to 50 ppb.

As an initial evaluation of the chamber, experiments with insects were conducted; they are relevant to closed-loop ecosystems. In addition, these experiments were also relevant to global terrestrial biogeography because of the tendency of insects to be distributed at lower pressures by high-altitude winds. These experiments were designed to validate the system for use with a biological component. Respiration at well-defined decrements of pressure in the chamber were studied. A wide diversity of insects from detritavores to pollinators that may be important in closed-loop ecosystems was examined. Using the chamber's automated pressure systems, the lower threshold (about 50 mb) at which a closed-loop ecosystem could be operated while still maintaining the viability of an insect component was determined. This pressure is some four times lower than the lowest pressures at which plants

begin to show detrimental effects. Thus the conclusions that in closed-loop ecosystems with reduced pressures (which are desirable to reduce gas usage and reduce engineering constraints), an insect/pollinator component is compatible. Furthermore, it was demonstrated that insect tolerance of pressure reductions is consistent with postulated mechanisms for biogeographic wind distribution in the terrestrial upper troposphere.

The system was optimized throughout these experiments. Further work is now being undertaken with cyanobacterial mats to assess the long-term effects of a range of CO_2 concentrations on their metabolism over a long duration (weeks). These cyanobacterial mats come from Baja, California, and the particular species of bacteria, Lyngbya, is similar to some of the early microfossilized terrestrial life. Because these cyanobacteria produce oxygen, the evolution of oxygen with the gas chromatograph system is being sensitivity measured to quantify the net photosynthetic rate over time and assess the role of pressure and CO_2.

Significance of the results

The results from this study have met the following goals: (1) adaptation of an existing pressure system to incorporate the capability to simulate atmospheric conditions representative of the early planetary environments on Mars (and also on Earth); (2) quantitative measurement of the effects of pressure on some organisms; (3) development of a methodology to measure the effects of atmospheric gases on organism metabolisms, with a focus on bacterial photosynthetic life; and (4) an effort to begin to evaluate the metabolism effects on some candidate bacterial species. Further work will continue to glean research results and publications from the new facility that has been constructed. Ames has been designated as the lead NASA center for Astrobiology, concerned with the origin, evolution, and distribution of life in the Universe. A facility has been developed that can now be used further for numerous studies of relevance in astrobiology. Experiments that test the ability of life to survive under low pressures (common on many planetary and satellite surfaces) and under different gas concentrations are of fundamental interest. The facility also has the capability to make measurements of organism response relevant to human survival in long-duration space missions with architectures incorporating closed-loop life-support systems and needing accurate information on organism response. Finally, NASA is concerned with detecting planetary systems around other stars by spectroscopy. But which planetary atmospheres are outside the bounds for life? Based on a preliminary assessment, a planet with 95-percent CO_2, for example, can support some simple species and would be worth a continued investigation for life. Similarly, this study found that even animal (insect) life can survive in planetary atmospheres with pressures down to <0.1 bar.

Publications resulting from the study

Cockell, C. S.; Catling, D. C.; and Waites, H. F.: Insects at Low Pressure: Applications to Artificial Ecosystems and Implications for Global Terrestrial Distribution. Life Support and Biosphere Science (in review), 1998.

Keywords

Closed-loop ecosystems, Gas chromatography, Life on Mars

Active Control of Instability Waves in a Laminar Boundary Layer

Investigator(s)

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Anthony Dietz, MCAT Institute, Ames Research Center

Objectives of the study

An active wave cancellation scheme for the control of transition in a laminar boundary layer is to be developed and tested. The method will use spanwise-distributed disturbance sources to excite control waves that cancel instability waves detected in the boundary layer. Superposition of the control waves on the instability waves reduces the magnitude of the instabilities, leading to a delay in transition. A major objective of this work is to demonstrate that three-dimensional instabilities in a boundary layer can be successfully controlled. The use of spanwise-distributed disturbance sources with independent amplitude and phase controls gives the method this capability. However, the ability of an array of discrete excitation points to excite continuous wave fronts and the linearity of the superposition of these waves are open questions, which must be answered.

Progress and results

An existing flat plate receptivity experiment in the NASA Ames Fluid Mechanics Laboratory's 15-inch low-turbulence wind tunnel was modified to include an active wave cancellation unit. This experiment utilized a vibrating ribbon positioned upstream of a flat plate to excite instability waves in the plate boundary layer. These waves provided a known and repeatable input into the control scheme. The control unit was installed on a removable section of the flat plate to allow different instrumentation and actuator configurations to be easily installed and removed. The cancellation scheme consisted of two rows of sensors followed by a row of actuators. Two sensor rows were required in front of the actuators to give streamwise spatial information on the approaching waves. Small electret microphones were used as the sensor elements and small earphones as the actuators. A schematic of the control unit is given in figure 1. The mounting arrangements for the microphones and speakers were determined from tests and analyses performed to optimize the frequency response of the sensors. The wind tunnel data acquisition and processing capabilities were expanded to cope with the increased number of channels and the real-time processing requirements of the control unit. Software control of the new hardware was implemented using LABVIEW graphical programming software.

The microphone sensors were located 0.55 m from the leading edge of the flat plate, which corresponded to an $R = \sqrt{Re}$ of 800 at the test velocity of 17 m/s. This location was estimated to be the lowest Reynolds number at which Tollmien–Schlichting (TS) waves would be detectable. Initial measurements were hampered by the imperfect rejection of acoustic disturbances by the microphone pairs. At such a close spacing, the differential signal between two successive microphones should respond primarily to short-wavelength TS waves and not to longer-wavelength acoustic waves. This problem was overcome by exposing the microphones to sound from the downstream speakers with the flow off. The gains of the microphones were then tuned until the differential signal no longer contained any component at the speaker driving frequency. However, filtering was still necessary for a clean control signal. The microphone signals used in the control tests were bandpass filtered between 140 and 500 Hz and amplified by a factor of 100 to make full use of the A/D range. With this setup, the microphones were able to detect wave trains and wave packets excited upstream by the vibrating ribbon.

Tests demonstrated that the local disturbances generated by the speaker/actuators did excite TS instability waves in the boundary layer. However, control effectiveness was limited by the magnitude of the control wave, which was limited by the maximum speaker power. The 8Ω earphones initially installed in the unit suffered from overheating at the high power settings required for adequate control. A limiting condition was reached where the maximum control wave amplitude could barely cancel the minimum detectable instability wave. To overcome this limitation, the 8Ω speakers were replaced by 32Ω speakers of the type found in stereo headphones. The newer speakers increased the power of the disturbance, but the higher power settings tripped the flow at the speaker hole through a bypass transition mechanism. This problem was overcome by installing each speaker behind a pattern of nine holes. The new arrangement distributed the disturbance over a larger area, reducing the peak velocity and preventing bypass transition. The improved actuators provided adequate control authority.

The performance of the spanwise-distributed speakers in exciting two- and three-dimensional waves is shown in figure 2. The highly three-dimensional local disturbances excited by the actuators rapidly decay (within three wavelengths) while the TS wave grows exponentially. Measurements of the downstream wave train excited by different actuator combinations showed that the superposition process was linear within a certain excitation range. The pattern produced by the eight actuators was equal to the sum of the patterns produced by each of the actuators when acting alone. Thus a required wave pattern could be obtained by solving an optimization problem where the difference between the desired wave pattern and the sum of the individual actuator patterns was the parameter to be minimized, and the magnitude and phase of each of the actuators were the parameters to be varied. The three-dimensional control wave used to cancel the wave train excited at a point source upstream of the control unit was obtained in this manner using the optimizer provided in the Excel spreadsheet.

The initial control scheme was a simple invert and delay strategy. The input instability was a two-dimensional wave train excited by the vibrating ribbon positioned in the free stream ahead of the plate. At first, control was attempted by driving the speakers with a phase-delayed copy of the signal driving the vibrating ribbon. This control attempt was not successful because with the ribbon such a large number of wavelengths ahead of the control site, small variations in free-stream velocity introduced large variations in the phase of the TS waves approaching the control unit. The result was that the control unit oscillated between attenuating the instability and reinforcing it. Feedback control was implemented using the differential signal between the two upstream microphones as its input. This scheme proved successful. The result can be seen in figure 3.

The turnaround time of the processor was of the order of 100 ms. With the microphone/speaker separation used in this study, real-time control would require a turnaround time of 1 ms. As a result, feedback control was possible only for wave trains, and the scheme could not be tested against wave packets where real-time detection and control are required.

In order to test the control scheme against three-dimensional waves, a known and repeatable three-dimensional instability wave input was required. Attempts to excite three-dimensional waves with artifically generated free-stream disturbances proved unsuccessful. The vibrating ribbon was replaced by numerous different arrangements, of which a low-aspect-ratio wing made from 0.001-inch stainless steel shim proved the most successful. However, the wave pattern produced by this device was more of a spanwise-limited two-dimensional wave than a three-dimensional wave with significant oblique components. It was therefore decided to use a harmonic point source excited by a speaker mounted in the plate upstream of the control unit to generate the three-dimensional instability wave.

The magnitude and phase of the three-dimensional instability wave was measured downstream of the control unit, and the optimal magnitude and phase for each actuator was determined using the technique described previously. Application of the control scheme resulted in a 75-percent reduction in the magnitude of the three-dimensional wave along the complete wavefront.

Significance of the results

The potential benefits of laminar flow control in reducing aircraft or ship drag and improving manufacturing processes are large and justify the pursuit of numerous control techniques. Wave cancellation studies carried out previously have involved surface-generated instability waves or uncontrolled free-stream-generated waves, limiting the breadth of the studies and the degree to which the cancellation technique could be optimized. In addition, there has not been a concentrated effort to introduce or cancel any three-dimensionality in the instability waves. The feasibility of actively canceling two- and three-dimensional TS waves with control waves generated from spanwise-distributed actuators has been demonstrated in this experiment. The significant result of this investigation was the successful cancellation of a three-dimensional instability. Such instabilities are representative of that generated when surface holes or bumps interact with free-stream disturbances. Following this demonstration of the feasibility of three-dimensional cancellation, the next step will involve improvements in the control algorithms relating the detector signals to the actuator outputs so that real-time control may be achieved.

Publications resulting from the study

Dietz, A. J.: Active Control of Instabilities in a Laminar Boundary Layer. AIAA Paper 99-0922, presented at the 37th Aerospace Sciences Meeting, Reno, Nev., Jan. 11–14, 1999.

Keywords

Boundary layers, Laminar flow control, Active flow control, Transition

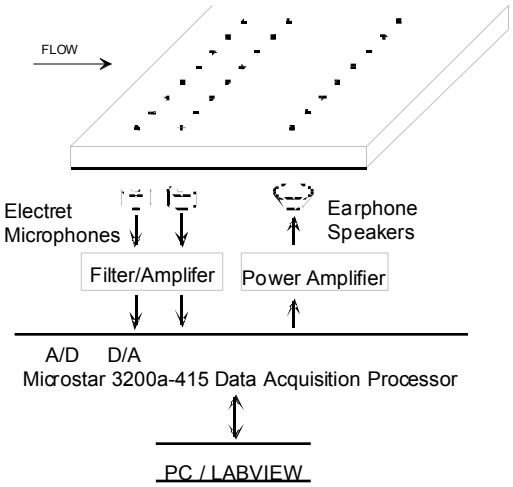


Figure 1. Control scheme.

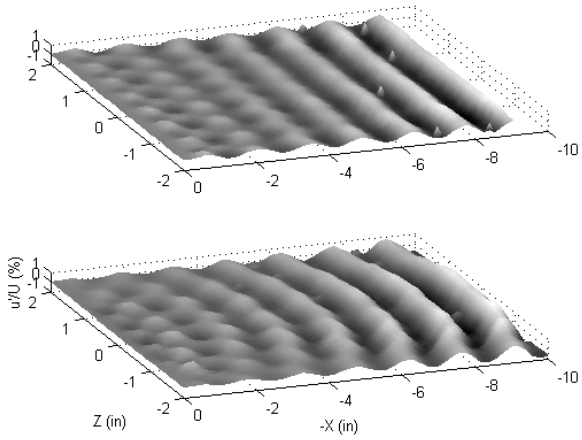
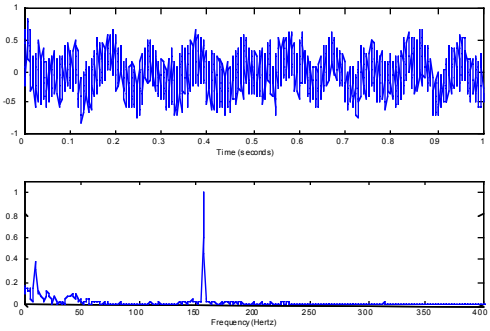
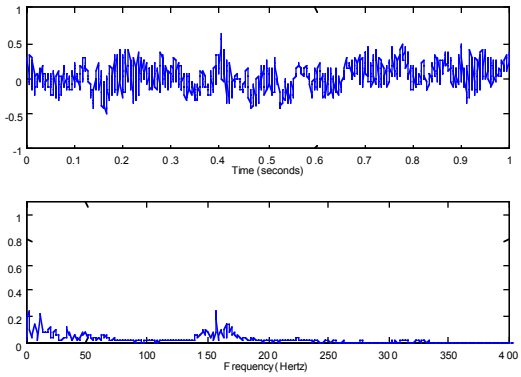


Figure 2. Streamwise velocity fluctuations in the boundary layer downstream of control actuators. Control wave only; no instability wave present. In the upper plot the actuators are configured for canceling two-dimensional waves; in the lower plot the actuators are configured to cancel the three-dimensional wave train from a harmonic point source.



Control OFF



Control ON

Figure 3. Hot wire signal downstream of control unit. Boundary layer excited by the wake from a vibrating ribbon located upstream. Control based on signals from microphone sensors.

Early History of the Biogeochemical Carbon Cycle Can Be Illuminated by Isotopic Microanalyses of Rocks Using a UV Laser

Investigator(s)

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Objectives of the study

Measurements of the stable isotopic composition of carbon in ancient sedimentary rocks offer a valuable insight into the early history of our biosphere. For example, ^{12}C and ^{13}C can be utilized at different rates by microorganisms. Therefore, patterns of abundance of ^{13}C versus ^{12}C in organic matter versus carbon-containing minerals can offer clues regarding the metabolism of ancient biota. Also, through isotopic mass balance calculations, changes in the relative sizes of organic versus inorganic sedimentary carbon reservoirs can be estimated over geologic time. Major advances in interpreting isotopic patterns in ancient rocks will depend upon our ability to sample very small bits of carbon-containing material in situ. This requires that carbon be volatilized from sample target areas having diameters in the range 1 to 100 μm. Current state-of-the-art isotope mass spectrometry can accommodate such small samples, and at a rate sufficient to create a large, statistically sound database in a short time. This technique would also benefit analyses of extraterrestrial materials such as meteorites and planetary materials.

This research proposed to assemble a laser-ablation system that could reliably release carbon from organic matter or carbonate in a 3- to 100-μm-diameter spot size and convert this carbon to CO_2 for stable isotopic analysis. The isotopic discrimination associated with the process must be either insignificant or else highly amenable to a correction procedure. Organic carbon should be combusted quantitatively. Carbonates should be converted principally to CO_2, and any other products should also be analyzed to yield accurate measurements of $^{13}C/^{12}C$ and $^{18}O/^{16}O$. Ultimately, samples as small as 10^{-9} moles should be produced in order to take full advantage of state-of-the-art isotope mass spectrometry and to address effectively the projects outlined above.

Progress and results

The microsampler incorporates a frequency quadrupled Q-switched Nd:YAG laser with a 266-nm output that will generate from 0.2×10^{12} to 1.5×10^{12} joules/cm^2 onto a spot 10 μm in diameter. Through processes of photoexcitation, this laser decomposes carbonates and, with O_2 present, combusts organic carbon. The laser can photoexcite organic carbon, causing it to combust in the presence of O_2. The power output of the laser can be attenuated and the spot size adjusted from 5 to 400 μm, and the even power density within the beam creates flat-bottomed pits. The views of both the microscope and the video camera are coaxial with the laser beam and have image magnifications ranging from 50x to 800x. The sample chamber is movable, relative to the laser beam, using a motor-driven x-y stage. The sample chamber can be interfaced with a Finnegan Delta+ mass spectrometer that has a sample requirement of only 10^{-10} moles. The gases released from the sample are swept through a coiled quartz tube within a 700°C oven, which converts carbon in microparticulate carbonates and CO to CO_2. Previously characterized carbonate rocks are analyzed to document that the new technique recreates the $^{13}C/^{12}C$ patterns that had been verified previously among the various carbonate mineral phases in the rock matrix.

Significance of the results

The new discipline of astrobiology seeks to interpret the early evolution of Earth's environment and biosphere and to search for evidence of prebiologic and/or biologic evolution elsewhere in our solar system and beyond. Much of this evidence resides in rocks that preserve the remains of biota and organic matter. This material is preserved as particulates in the submillimeter size range. Therefore, microsampling must be performed at the scale of 10s of μm or less. Applications of this methodology go beyond ancient sediments to include extraterrestrial samples such as meteorites, cosmic dust, and planetary samples.

This work offers several novel aspects. This is the first use of a UV laser for isotopic microanalysis of carbon. Use of UV light avoids problems of isotopic discrimination associated with partial release of carbon from an adjacent "halo" region around the sampling pit. This is the first laser-assisted combustion of organic carbon in situ for stable isotopic analysis. Also, these will be the first subnanomole-sized solid carbon samples to be measured isotopically.

This laser system will help to establish Ames as a leader in the isotopic microanalysis of a wide variety of biologically relevant materials from Earth's early rock record and from extraterrestrial materials. Microanalytical methods such as this will improve Ames' position as a possible future recipient of a returned Mars sample. Mars sample return is a key objective for the currently funded Mars Surveyor Program; the mission launch is scheduled for 2005.

Keywords

Laser, Rocks, Carbon

Miniaturized Haptic Interface for Precision Haptic-Visual Interaction

Investigator(s)

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Other personnel involved

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Objectives of the study

To design, build, and evaluate a small-scale force-reflecting haptic interface for precision manual interaction with virtual and teleoperated environments. A haptic interface is a mechanical device (e.g., joystick) and associated software that permits the user to feel forces from computer-generated virtual environments or computer-mediated teleoperated environments.

Beginning from the innovative three-degree-of-freedom (three-DOF) kinematic architecture for haptic interfaces and robot manipulators (Adelstein et al., 1996; Adelstein, 1998 patent) shown in figure 1, we seek to develop a miniature joystick matched specifically to the range of motion and force exertable by the thumb and index finger when engaged in a precision grasp (i.e., pencil grip) with the wrist supported. Part of the machine design goal is development of analysis tools to: 1) define essential geometric tolerance features for successful assembly of the mechanism; and 2) permit a statically (mass) balanced implementation of the complex spatial architecture.

The specific machine being built is to be used in a series of human performance studies to ascertain correlations between human performance metrics and engineering characterizations of haptic interface quality (i.e., linkage, actuator, and mechatronic control properties). The intended outcome is for such performance data and resulting models to contribute to a set of standards or guidelines for the development of high-fidelity equipment for rendering of "palpable" mechanical features.

Progress and results

Both requisite analytic tasks were completed.

The geometric tolerance analysis was performed through a series of three-dimensional graphical constructions for a more general spatial version of the 10-link, 12-revolute joint, three-closed-loop mechanism in figure 1. The results of this analysis indicate that successful fabrication and assembly of the mechanism requires only the coplanarity of adjacent joints within each spherical link portion of the mechanism and parallelism of adjacent joint axes in the planar link portions. Design constraints (other than loop closure) are unnecessary for assembly.

The mass balance analysis derives from an accounting of potential energy attributable to the weight distribution of each link and changes in potential energy because of variable angular displacements. Differentiation of these trigonometric expressions (for a Lagrangian dynamic formulation) indicates the pose-dependent endpoint force or actuator torques required to balance the weight of all links. This potential energy tally yields 12 coefficients which, when zeroed, eliminate net gravity force (torques) on the mechanism endpoint (actuators), regardless of pose or orientation of the gravity vector. Simple link symmetry reduces seven of the coefficients to zero. Mass redistribution among groupings of links can eliminate the remaining five. In practice, we were able to zero 10 coefficients. Because of interference to internal linkage motion, the remaining two coefficients are minimized rather than zeroed.

A first linkage design with an internal link arrangement modified from earlier configurations (Adelstein et al., 1996; Ho, 1996) was assembled in July 1998. A second machine, which incorporates results from the mass-balance analysis, was designed and is presently being assembled.

Following a port of haptic control software from the earlier large-scale machine (Ho, 1996) to the new finger-scale joystick, and calibration of the mechanism and its control, a series of human motor and perceptual studies will begin.

Significance of the results

Because of the three-DOF architecture selected, hardware performance benefits from 1) rotary actuators fixed to a common base that reduce inertia, weight, and power consumption, and 2) a parallel kinematic mechanism that

offers high structural stiffness while still maintaining a large reachable workspace.

The geometric tolerancing analysis for this machine enabled the complexity of individual links to be reduced and the required machining precision for components to be relaxed (cf. Ho, 1996). This setup allowed for simpler part geometries to be selected, in turn reducing the complexity, cost, and time to machine and assemble the three-DOF interface mechanism.

Furthermore, the improved mass balance characteristics of the new implementation reduce (or ideally eliminate) the actuator torques needed to support the interface mechanism against gravity, thereby allowing the device to be driven by smaller, less-expensive motors.

Publications resulting from the study

Adelstein, Bernard D.; Ho, Peter; and Kazerooni, H.: Kinematic Design of a Three Degree of Freedom Parallel Hand Controller Mechanism. Proceedings of the Dynamic Systems and Control Division Am. Soc. Mechanical Engineers, Dynamic Systems and Control Division DSC v.58, New York, N.Y., 1996, pp. 539–546.

Ho, P. P-M.: Kinematic Analysis and Prototype Design of a 3-Degree-of-Freedom Hand Controller. MS project report. Dept. Mechanical Engineering, University of California, Berkeley, 1996.

Adelstein, B. D.; Gayme, D. F.; Kazerooni, H.; and Ho, P.: Three Degree of Freedom Haptic Interface for Precision Manipulation. To appear in Proceedings, Dynamic Systems and Control, Am. Soc. Mechanical Engineers, New York, 1998.

Adelstein, Bernard D.: Three Degree of Freedom Parallel Mechanical Linkage. U.S. Patent No. 5816105, Oct. 6, 1998.

Keywords

Haptics, Virtual environments, Robotics, Manipulator kinematics

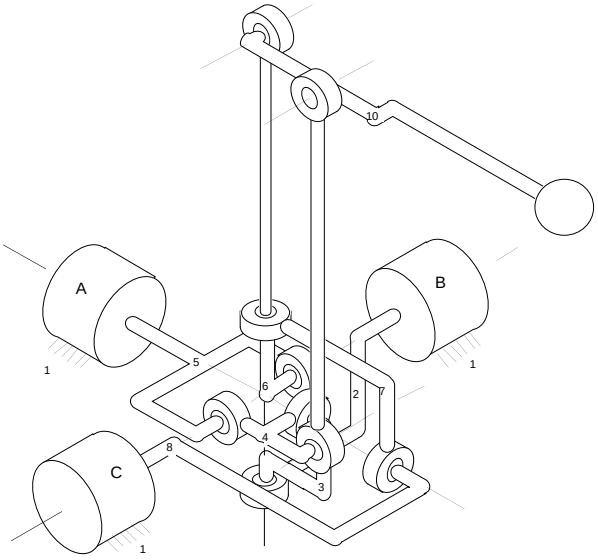

Figure 1. Three-degree-of-freedom, 10-link, 12-revolute joint haptic interface architecture. Rotary actuators A, B, and C share a common base/ground (link 1).

Laminar Flow Fairings for Acoustic Sensors and Arrays

Investigator(s)
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Other personnel involved
Chris Allen, Ames Research Center

Objectives of the study
Several recent wind tunnel aeroacoustic test programs have utilized phased microphone acoustic arrays to measure the locations and levels of noise sources associated with high-lift and propulsion systems for both subsonic and supersonic aircraft configurations. These test programs have been conducted at Ames in the acoustically treated 40- by 80-Foot Subsonic Wind Tunnel, as well as the hard-wall test sections of the 7- by 10-Foot Subsonic Wind Tunnel and the 12-Foot Pressure Wind Tunnel. In each of these prior tests, the noise sources have been relatively strong, and the array has been located close to the test article. Size of the arrays has ranged from 0.6 to 1.5 meters (2 to 5 ft).

Future research programs will need to accurately measure lower noise levels, because of the success of ongoing noise reduction efforts such as pursued by the Advanced Subsonic Technology and High-Speed Research programs. Additionally, future studies will require advanced measurements, such as source directivity, which involve traversing the array further from the model. Accurate measurements in these situations is presently a difficult challenge because of high levels of sensor self-noise associated with turbulent flow over the sensor fairing. Although this problem is avoided by taking array measurements outside the flow of an open jet wind tunnel, this approach limits the Reynolds number and introduces scattering and other errors in the measurements.

This study was a preliminary investigation of the feasibility and effectiveness of using natural laminar flow (NLF) and suction hybrid laminar flow (HLF) fairings to reduce sensor self-noise. The goal of this research is to generate baseline reference data and guidelines for designing fairings for both small and large arrays for future aeroacoustic research.

In idealized situations, with very low levels of free-stream turbulence energy, acoustic background noise, and surface roughness, calculations of transition by Schlichting and others predict transition Reynolds numbers on the order of 5×10^6 for natural laminar flow airfoils and 20×10^6 for properly shaped airfoils with suction hybrid laminar flow control. These values imply that reasonably sized arrays can be designed that achieve quiet, laminar flow over the sensing area. However, in a typical large-scale wind tunnel environment with turbulence intensities on the order of 0.25 percent, and with surface roughness associated with conventional fabrication methods, transition Reynolds numbers are substantially reduced. The challenge for this application is to maintain laminar flow over the sensing area of the fairing through management of pressure gradient (fairing shape), surface roughness, and possibly suction flow control.

Specific objectives in this study were as follows:

1. Modify an existing small-scale research wind tunnel to produce acoustic background noise levels and onset turbulence levels comparable to the three large wind tunnels listed previously.
2. Design and fabricate prototype fairing sections for both NLF and HLF installations of conventional microphones.
3. Predict fairing pressure distributions and separation locations.
4. Characterize acoustic background levels and onset turbulence energy distribution in the modified research wind tunnel.
5. Measure NLF fairing effectiveness in terms of transition location as a function of Reynolds number and incidence angle.
6. Quantify suction HLF fairing effectiveness in terms of transition location as a function of Reynolds number, incidence angle, and suction distribution. Also characterize effects of suction port ingestion of turbulence on background noise level.
7. Prepare NLF fairing for evaluation in the 40- by 80-Foot Subsonic Wind Tunnel test section as part of the Integrated Systems Test of that facility following the recently completed acoustic upgrade.

Progress and results
In a cooperative effort with Integrated Instrumentation and Test Systems (IITS) funded research of quiet isolated microphones (Chris Allen), the 14-Inch Indraft Wind Tunnel in the Fluid Mechanics Laboratory, Test Cell #3, was successfully modified to generate acoustic background noise levels and onset turbulence energy comparable with levels in the 40- by 80-Foot Subsonic Wind Tunnel. This effort involved design and fabrication of a muffler to

reduce strong acoustic background levels originating from downstream of the test section, modifications of the inlet section to provide control of the inlet turbulence levels, and fabrication of new removable, acoustically treated test section walls. As a result of this work, the 14-inch tunnel research capability has been substantially improved, and is planned for use in future research of this type. Common instrumentation, calibration, signal conditioning, and data-acquisition equipment was shared between the two programs.

Two fairings, with 20.3-cm (8-in.) chord and 35.6-cm (14-in.) span were designed and fabricated from composite materials. Commercially available 1/4-in. microphones and flush-mounting hardware were used for five sensors on the NLF airfoil, and three sensors on the HLF airfoil. These microphones and mount fixtures are similar to those currently used in phased microphone array designs. Static pressure taps were installed in the two fairings to compare measured pressure distributions with predictions. The fairing models were tested at 50, 100, and 150 knots, with corresponding Reynolds numbers of 3.5×10^5, 7×10^5, and 1.4×10^5. The highest speed corresponds to a Mach number of 0.22, which is a typical landing-speed condition for large-scale aeroacoustic testing. Reference noise levels were measured with a conventional isolated microphone fitted with a low-noise forebody. Empty-test-section turbulence levels were measured with an X-wire probe. An inlet configuration that produced approximately 0.25-percent test section turbulence was selected for this experiment.

NLF fairing results

The NLF fairing was a 22-percent-thick airfoil with maximum thickness located at 50-percent chord. This shape was selected to generate a favorable pressure gradient on the forward half of the fairing. Microphones were placed at 22-, 38-, 50-, 62-, and 78-percent chord locations. The airfoil surface was smooth to within 10 microns, and the microphone and mounting were flush with the airfoil surface to within 100 microns. Within the extent of laminar flow, the acoustic spectra of the flush-mounted microphones on the NLF fairing were similar to the spectra from the isolated microphone, except for a 6-dB broadband increase due to reflection at the airfoil surface. The flow was laminar at the 38-percent chord microphone location at 100 knots within an incidence range of ±2.7 deg, which is typical for acoustic probes of this application.

HLF fairing results

The HLF fairing was the same shape as the NLF fairing, with porous suction patches in front of the first three microphones. The porous screen was smooth to within 10 microns, except at the edges, which deviated from the level of the surrounding surface by 20–100 microns. As a result, the flow transitioned earlier than for the NLF fairing. Suction at the furthest upstream patch was effective in restoring laminar flow only to the first microphone location. Suction coefficients of about 1.5 percent were required to affect transition; this is an order of magnitude higher than typically required for suction control on a flat plate. Even at these high suction levels, the microphone background noise level was not noticeably degraded by the suction control.

Significance of the results

These results demonstrate that laminar flow can be maintained over flush-mounted microphones in a suitably shaped fairing, in moderate levels of turbulence and surface roughness, and for ranges of incidence angle typically encountered during aeroacoustic testing. Since completing this study, microphones with smoother diaphragms have become commercially available. This should improve the ability to maintain laminar flow at higher speeds over greater extent of the fairing surface.

In addition to source location arrays that range from 0.3 to 1 meter, smaller arrays from 0.1 to 0.2 meter have been used to improve signal-to-noise ratio over a wide beam for source-level measurements. The results of this study can also be applied to these types of measurements.

The NLF fairing has been adapted for evaluation in the 40- by 80-Foot Subsonic Wind Tunnel in the near future. Free-stream turbulence near the fairing and background noise will be measured for comparison with conventional probes and with the results from the 14-Inch Indraft Wind Tunnel in the Fluid Mechanics Laboratory.

Keywords

Acoustic sensors, In-flow microphones, Wind tunnel noise

Microwave Remote Sensing of Thermal Protection Materials for Vehicle Health Monitoring

Investigator(s)

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Objectives of the study

To investigate microwave techniques for remote monitoring of the status of thermal protection materials used on spacecraft such as the Space Shuttle. Considerable effort is expended in human inspection of the thermal protection system (TPS) after each flight. Automated inspection holds the potential for significant cost savings important to commercialization of space technology.

Progress and results

The basis of this technique is the sensitivity of microwave emission to the surface geometry and the dielectric properties of the TPS materials. Surface geometry includes the horizontal and vertical arrangement of the TPS materials on the skin of the vehicle and includes the presence or absence of gaps such as intentional spacing between adjacent tiles and those due to charring of the filler bar or the strain insulator pad. Measurements of the dielectric constants of TPS materials show them to be translucent at microwave frequencies, allowing sensitivity to subsurface conditions.

Sensitivity studies of microwave emissivity as a function of TPS conditions have been conducted and a prototype radiometer for monitoring TPS health has been designed and fabricated. A microwave radiometer measures an apparent brightness temperature, which is the product of the emissivity, and the physical temperature. The expected sensitivity of microwave emission to TPS conditions has been simulated using a layered-media model based upon TPS dielectric properties and typical physical dimensions. These simulations show emission to be dependent upon both sensor characteristics (i.e., viewing geometry and wavelength) and target properties (i.e., the thickness of the thermal tiles and gap dimensions). Sensitivity to gap dimensions is sufficient for ready detection, provided we normalize for the other variates. This suggests using a procedure incorporating a "change-detection" methodology whereby the TPS is imaged by a microwave radiometer before and after flight to quickly identify areas that need further inspection. An alternative, though higher-cost, method to normalize for tile thickness and viewing geometry uses a dual-frequency approach to resolve ambiguities in emissivity.

A site visit was made to the orbiter processing facility at Kennedy Space Center in June. The current TPS inspection process was reviewed and the facility was examined with respect to radiometer design and siting considerations. Two potential implementation strategies were identified: (1) standalone operation of a radiometer within the Orbiter Processing Facility (OPF) bay at the Kennedy Space Center to scan the orbiter TPS via repositioning of the radiometer and (2) integration of a radiometer array into a structure that the orbiter could roll past (such as the OPF bay entrance). Each strategy has advantages that need to be further explored.

Another potential use for the radiometer may be for viewing hot spots on a reentry vehicle immediately after landing. Excessive hot gas penetration between tile gaps may lead to slow local cooling near the breached area. Detection of these hot spots will provide a warning that further inspection is required. This approach has been taken using infrared (IR) detectors, but microwaves may be more sensitive to defects deeper in the TPS material. This approach may be the least costly in terms of development and implementation.

In order to validate our hypothesis, a prototype radiometer operating at 94 GHz has been designed and fabricated. This state-of-the-art radiometer is used by the University of Michigan to measure the emissivity from panels of TPS tiles fabricated by Ames Research Center. The instrument operation and sensitivity will be experimentally verified using these mock-up panels. The panels include both nominal TPS conditions and various failure modes. Test results will guide selection of the proposed implementation methodology and any needed refinements to instrument design for future launch vehicle applications.

The figure shows the internals of the 94-GHz Dicke radiometer designed and built at the University of Michigan's Radiation Laboratory in Ann Arbor, Michigan. The components of this device are housed in a 3/8-inch aluminum frame that was milled and assembled in the Ames machine shop. The narrow beam antenna has moderate gain and a 1.5-degree beam width. There are two large heat sinks used to help minimize temperate gradients in the radiometer as small shifts in the physical temperate of the millimeter wave and base band components may

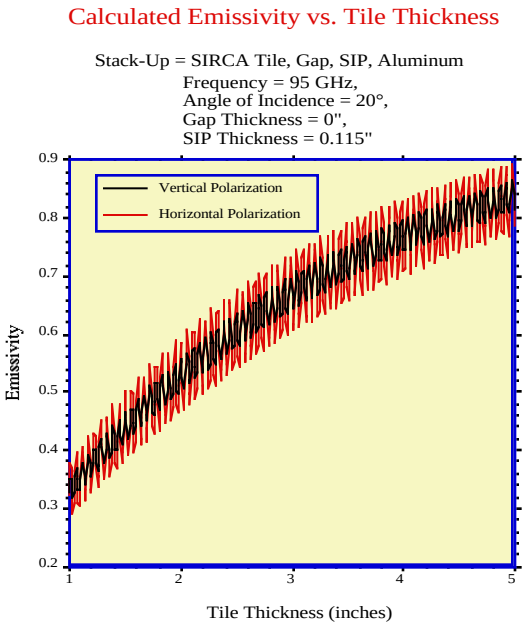
cause large errors in measurement. There is a silicon resistive heating element affixed to the sink on the right of the structure (looking from back to front), which, with the assistance of a DC fan, transfers most of its heat to the air. The two IF amplifiers are affixed to the second sink, which aids in dissipating their excess heat and helps to stabilize their gain. Also visible on the right side of the frame are a bank of regulators and a voltage divider network used to supply the various active components.

Keywords

Vehicle health monitoring (VHM), Microwave emission, Thermal protection system (TPS)

Relative Dielectric Constant of Shuttle Thermal Protection System Materials

Material	Relative Dielectric Constant		
	15 GHz	16 GHz	94 GHz
SIRCA	1.455, 0.127	1.502, 0.141	1.298, 0.040
FRCI-12	1.352, 0.102	1.405, 0.115	1.253, 0.030
SIRCA-12	1.535, 0.145	1.598, 0.159	1.159, 0.128
AETB-8	2.313, 0.327	2.373, 0.367	2.280, 0.052



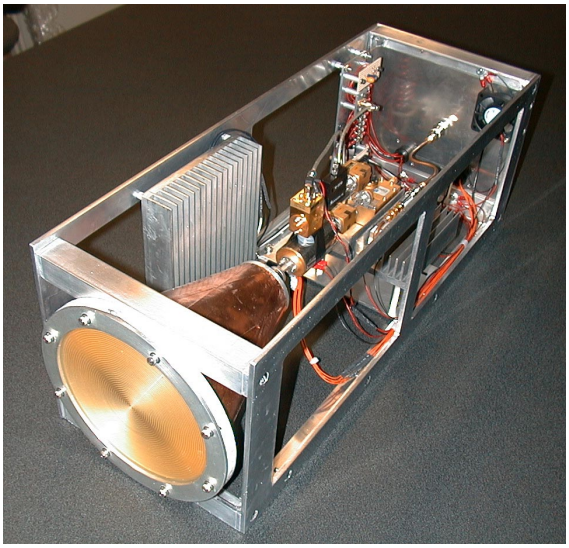


Figure 1. Radiometer.

Design and Study of Carbon Nanotube Electronic Devices

Investigator(s)

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Jie Han, MRJ, Inc., Ames Research Center

Objectives of the study

Carbon nanotubes exhibit remarkable properties that could be exploited for use in nanoscale electronic devices such as diodes, transistors, and sensors. In this study we seek both to understand the nature of these properties using accurate modeling and simulation techniques and to start designing nanoscale electronic devices based on nanotubes.

Progress and results

It has been confirmed theoretically and experimentally that carbon nanotubes can be metallic or semiconducting, depending on their chirality, and that the band gap of semiconducting tubes is a simple function of tube diameter. This research further shows that a variety of nanotube devices can be formed by chemical and/or mechanical modification of nanotubes. We propose two-, three-, and four-terminal junctions for use in nanoscale diodes, transistors, and logic devices. The two-terminal junctions, connecting metal, and/or semiconducting nanotubes have been observed experimentally, and the chemical, mechanical, and thermal stabilities of these junction structures have been studied. A very sensitive response of electronic properties of nanotubes to mechanical deformations was found, and strain-induced metal-semiconductor transitions were observed. These results suggest that nanotubes can be used for nanoscale electromechanical systems (NEMS).

Significance of the results

The work provides potential solutions in a key area of miniaturization of electronic devices. As the semiconductor industry moves to smaller feature sizes of integrated circuits, electronic devices are being pushed to nanoscales by the development of nanolithography technologies and molecular electronics. Nanotubes will provide naturally formed components with well-defined nanoscale geometry, highly intrinsic electrical conductivity, and improved reliability and stability for nanodevice applications. They have advantages of both solid-state nanoelectronics and molecular electronics. This research has demonstrated, at least theoretically, that nanotubes can be building blocks for future nanoelectronics and nanocomputers.

Publications resulting from the study

Han, J.; Anantram, M. P.; Jaffe, R. L.; Kong, J.; and Dai, H.: Observation and Modeling of Single Wall Carbon Nanotube Bend Junctions. Phys. Rev. B, vol. 57, 1998, pp. 14983–14989.

Han, J.: Energetics and Structures of Fullerene Crop Circles. Chem. Phys. Lett., vol. 282, no. 2, 1998, pp.187–191.

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Anantram, M. P.; Yang, L.; Han, J.; and Lu, J.: Electromechanical Properties of Carbon Nanotubes. Paper submitted to Phys. Rev. Lett., 1998.

Yang, L.; Anantram, M. P.; Han, J.; Jaffe, R.; and Lu, J.: Bonding Geometries and Bandgaps of Carbon Nanotubes under Uniaxial and Torsional Deformations. Paper to be submitted.

Keywords

Molecular electronics, Nanoelectronics, Nanotechnology, Carbon nanotubes

Calculation of the Free Energy, Thermal Energy, and Entropy of Self-Assembling Nanostructures in Solutions

Investigator(s)

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Timur Halicioglu, Eloret Institute, Ames Research Center

Objectives of the study

The configurational stability of nanoscale particles is greatly influenced by the surrounding medium. In general, the effect exerted by the medium on a transformation or combination reaction is very important, and can influence reaction equilibria and rates considerably. The objective is to investigate the effect exerted by the solvent on a chemical system in equilibrium (or undergoing reaction). In this study, two different types of reactions (namely, isomerization and association reactions) taking place in aqueous solutions were considered. Investigations include the calculation of energetics controlling the reaction equilibria. Calculations are expected to provide additional information about the role played by aqueous solutions in various solvation processes, as well as in structural and configurational stabilities of solutes.

Progress and results

In the first part of this study, investigations were conducted to analyze isomerization reactions of the azobenzene molecule dissolved in aqueous solutions. Calculations were carried out to estimate energetics for the *cis* $\Rightarrow$ *trans* reaction taking place in water. In the second part, association reactions for methane and methylchloride molecules (dissolved in water) were investigated. The association reactions here were considered as *2 • monomer* $\Rightarrow$ *dimer*, and interaction energies were estimated for monomers and for the dimer, separately.

Investigations were conducted using NPT molecular dynamics procedures for T = 298 K and P = 1 atm. Simulations were carried out employing the Dreiding force field and using the Ewald sum technique to include long-range interactions. In the computational cell, up to 400 water molecules surrounded the solutes. Three-dimensional (3-D) periodic boundary conditions were imposed to maintain continuity. For an isomerization or an association reaction taking place in aqueous solution, the total energy change, ΔE_T, was calculated as: $\Delta E_T = \Delta E_{\{WW\}} + \Delta E_{\{SW\}} + \Delta E_{\{SS\}}$. Here, $\Delta E_{\{WW\}}$, $\Delta E_{\{SW\}}$, and $\Delta E_{\{SS\}}$ denote contributions coming from interactions among the water molecules, between the solute and the surrounding water molecules, and the strain energies (due to varying solute configurations), including any solute/solute interaction.

For the azobenzene molecule, calculations indicate that in water the *cis* form is energetically more stable than its *trans* form, while in the gas phase the opposite holds. The largest contribution to ΔE_T comes from the $\Delta E_{\{WW\}}$ part, indicating that interactions among the water molecules play the most important role. The $\Delta E_{\{SW\}}$ and $\Delta E_{\{SS\}}$ parts in this case contribute about 20 percent, and both favor the *trans* form. The *cis* form is favored in solution because it is less disruptive of the water/water interactions.

For the association reaction of methane dissolved in water, calculations indicate that the dimer formation is energetically favorable. In this case also, the largest contribution to ΔE_T comes from the $\Delta E_{\{WW\}}$ part (–11.0 Kcal/mole) indicating that interactions among the water molecules play the most important role in this association reaction. The contributions to ΔE_T coming from the $\Delta E_{\{WW\}}$ and $\Delta E_{\{WW\}}$ parts (1.6 and –0.6 Kcal/mole, respectively) are much smaller.

Calculations for the dimerization of methylchloride molecules indicate that the association reaction in this case is not an energetically favorable process. The largest contribution to ΔE_T comes from the $\Delta E_{\{SW\}}$ part (32.0 Kcal/mole) favoring the monomers in water because of the polar nature of the CH_3Cl molecule. The $\Delta E_{\{WW\}}$ and $\Delta E_{\{SS\}}$ parts (–14.0 and –6.0 Kcal/mole, respectively) together constitute about 2/3 of $\Delta E_{\{SW\}}$ in the opposite direction (i.e., both favoring dimer formation). This outcome is basically due to strong dipole/dipole interactions between methyl-chloride and water molecules.

Significance of the results

Results indicate that H_2O-H_2O interactions in the vicinity of solutes play quite an important role in the *cis-trans* isomerization reaction of azobenzene and also in the association reactions of CH_4 in aqueous solutions. This outcome is important in providing additional information (at a molecular level) about the nature of so-called “hydrophobic bonding,” which is operational between nonpolar molecular species dissolved in aqueous solutions. In the case of methylchloride, which is a polar solute, dipole/dipole interactions (between the solute and water molecules) were found to be the most important

factor favoring the presence of monomers in solution. Finally, this study clearly shows that the role played by the surrounding medium on the configurational and structural stability of solutes is important—a factor that may be employed in the synthesis of nanoscale particles of prescribed structures.

Keywords
Solvent effect, Isomerization, Association

Wireless Video Measurements of Rotor Blade Displacement and Deformation

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Objectives of the study
To demonstrate a portable system for the measurement of rotor-blade displacement and deformation. The approach uses single-view photogrammetry with the camera mounted on the rotor hub. Strobed illumination is used to freeze the blade motion. Retroreflective targets strategically placed on the blade upper surface make the blade motion readily visible. Portability describes the self-contained nature of the proposed system. Use of battery power for both strobe and camera and RF telemetry for transmission of the video signal eliminates the need for any slip ring.

Progress and results
An image acquisition and processing system has been assembled and tested in the laboratory. The NASA/High Technology Corporation Video Model Deformation software has been modified to permit the analysis of rotor blade images acquired at widely separated azimuthal positions. The system has been calibrated and used to process telemetered video from a nonrotating model rotor blade in the laboratory. Figure 1 illustrates the lab test of a model rotor blade undergoing torsional deformation under computer control. Video measurements of blade deformation (twist) will be validated by direct comparison with measurements from dial gage indicators placed adjacent to chosen targets.

System calibration using an inexpensive 16-mm lens resulted in calibration errors larger than anticipated. Lens distortion is apparently not accounted for in the current software. This problem is not serious and will be sidestepped by the use of fully corrected lenses for the immediate future. Analysis of a sequence of images showed the acquisition and analysis software to be robust and easy to use. A low-cost commercial video telemetry system was successfully tested over a distance representative of testing in the 80- by 120-Foot Wind Tunnel with no apparent image degradation.

Significance of the results
It is essential for the development and validation of helicopter computational fluid dynamics (CFD) codes that an accurate measurement of blade position be made available during wind tunnel testing. This measurement of blade position must include both rigid-body displacement and aeroelastic deformation. The results of this research effort to date have shown the feasibility of a simple and inexpensive blade deformation measurement system by demonstrating the functioning of each of the key components. Much work remains to be completed to refine the system to the point where it can be used in a wind tunnel test. That work will continue into next year.

Keywords
Photogrammetry, Rotor blade, Video

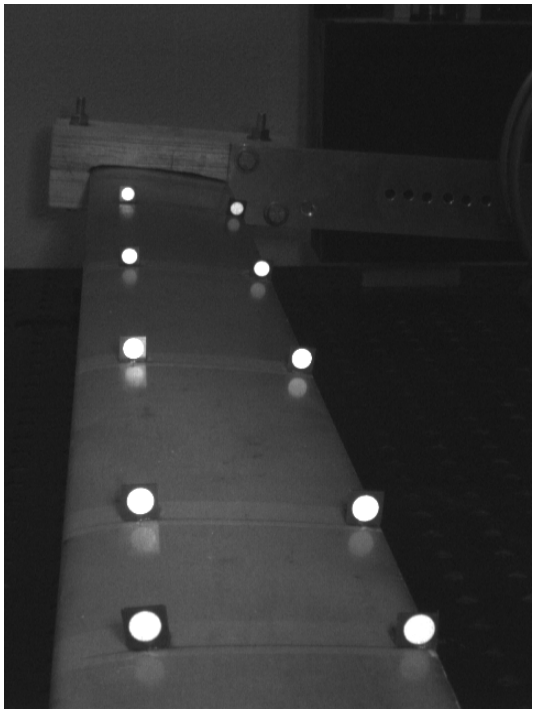

Figure 1. Torsional deformation of a model rotor blade.

Validation of a Nose-Channel Concept for Supersonic Drag Reduction

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Objectives of the study
To conduct an experimental proof-of-concept study to validate predicted lift/drag (L/D) performance enhancement at supersonic speeds for vehicle configurations designed with artificially blunted leading edge (ABLE) technology. The ABLE concept consists of a body with a well-designed hollow channel extending from the nose to the trailing edge (fig. 1). To accomplish this objective, drag and lift coefficients (C_D, C_L) for axisymmetric ABLE channel and baseline solid sphere/cone free-flying models were measured in the NASA Ames Ballistic Range. Experiments were also performed in the ballistic range to verify sonic boom signature reductions predicted with ABLE technology.

Progress and results
Significant progress was made in establishing the viability of ABLE channel technology as an effective aerodynamic performance enhancement technique. As shown in figure 2, Navier–Stokes simulations of bodies with and without channels predict that ABLE technology significantly reduces total drag over a range of Mach numbers. To experimentally validate the predictions at one free-stream condition, ABLE channel and baseline solid sphere/cone models were tested at M = 2.3 in the NASA Ames Ballistic Range (fig. 3). For these experiments, the channel was sized to choke the flow, creating an effective blunt body with reduced drag and increased lift. As shown in the pretest computations and ballistic range shadowgraphs (figs. 2 and 3), computational fluid dynamics (CFD) successfully predicts the predominant flow structures, especially the base-flow barrel shock and Mach disk features, consistent with experimental results.

Aerodynamic performance parameters, C_D, C_L, and L/D as a function of angle of attack were obtained for ABLE and baseline configurations using trajectory-based analysis from experimental shadowgraph and time-of-arrival information. The data, shown in figures 4 and 5, confirmed drag reduction, lift increase, and L/D performance enhancement trends predicted for ABLE channel geometries. The measured 35-percent nominal L/D performance increase at small angles of attack is considered very significant. Error bands for all measurements were calculated from a least square analysis.

Next, the effort was focused on measuring sonic boom signatures for ABLE and baseline configurations. To perform the measurements, 9 of the 16 side shadowgraph stations along the 75-ft ballistic range test section were modified and instrumented with transducer ports, to record pressure signatures of models in free flight. Corrections to the pressure signatures were made for Mach number, trajectory, and angle of attack differences. As shown in figure 6, a 12-percent bow wave boom reduction was measured for the ABLE channel configuration. The demonstrated measurements have generated interest from Lockheed Martin Skunkworks (LMSW) for application on advanced business jet designs.

Significance of the results
As a result of this research effort, funding has been obtained through a cooperative agreement between NASA and LMSW to evaluate integration of ABLE channel technology on a commercial vehicle. ABLE technology is also relevant to NASA's Access to Space programs with great payoff potential for reusable launch vehicles (RLVs). For planetary-entry, hypersonic, and supersonic-cruise vehicles, increased L/D can lead to greater range capability, increased payload mass fraction, improved fuel efficiency, and enhanced maneuverability. To demonstrate ABLE advantages, a Hypersonic Aircraft Vehicle Optimization Code (HAVOC)-based system trade study was performed on the X-33 vehicle modified with ABLE channel technology. The analysis resulted in an effective specific impulse (ISP) increase of 2 sec, maximum Mach number increase of 0.7, and increased range capability of 73 nautical miles (8 percent), enabling the X-33 to reach

Malmstrom Air Force Base in Montana. The next phases of the investigation will focus on expanding the test envelope to M = 8 and evaluating the use of ABLE technology for vehicle directional control.

Publications resulting from the study

Gupta, A.; Ruffin, S. M.; Yates, L.; and Newfield, M.: Aerothermodynamic Performance Enhancement and Design of Blunted Sphere-Cones Using the ABLE Concept. AIAA Paper 98-0897, presented at the 37th Aerospace Sciences Meeting, Reno, Nev., Jan. 11–14, 1999.

Keywords

Drag, Lift, L/D, ABLE, Channel, Supersonic, Hypersonic, Reentry

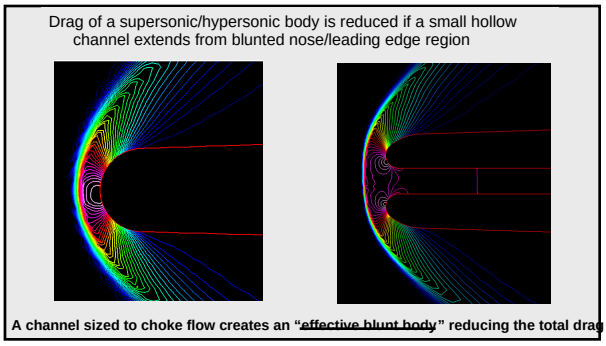

Figure 1. Artificially blunt leading edge concept (ABLE).

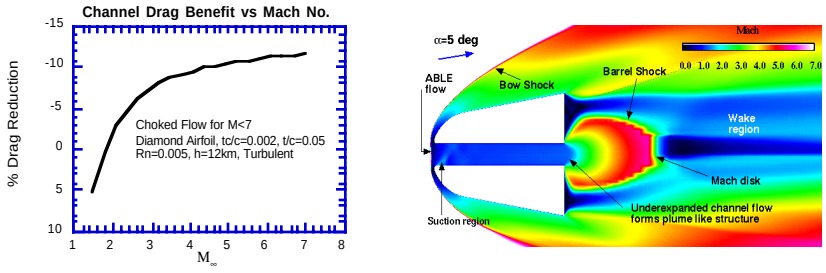

Figure 2. Navier–Stokes simulations of airfoils and axisymmetric bodies.

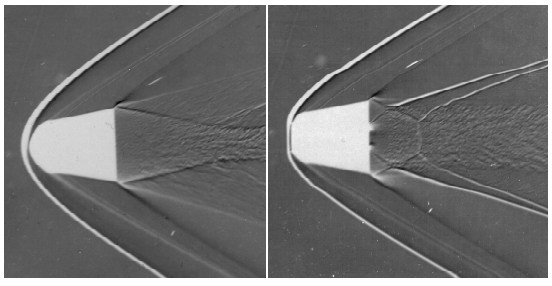

Figure 3. Ballistic range shadowgraphs of baseline solid sphere/cone (left) and ABLE models (right), M = 2.3, p = 1 atm, base dia. = 1 inch, length = 1.16 inches.

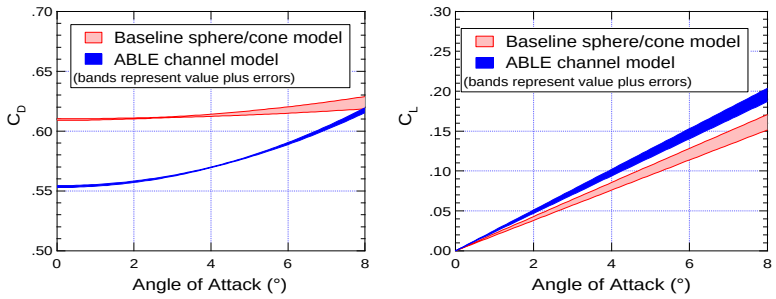

Figure 4. Experimental measurements of C_D, C_L vs. angle of attack for baseline solid sphere/cone and ABLE geometries, M = 2.3, p = 1 atm.

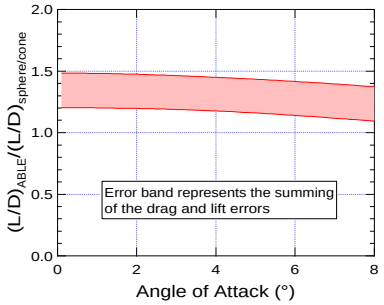

Figure 5. Measured L/D performance enhancement for the ABLE geometry, M = 2.3, p = 1 atm.

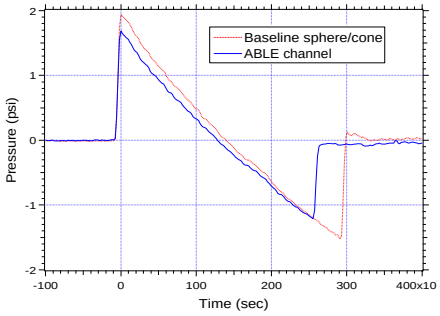

Figure 6. Experimental N-wave signatures for solid sphere/cone and ABLE geometries, M = 2.3, p = 1 atm, H/L ≈ 40.

Simulation Modeling Investigations of the Terrestrial Carbon Cycle

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Objectives of the study
To enhance collaboration between NASA Ames scientists working in the disciplines of (1) ecosystem science and (2) information technology. A major scientific problem that those working in Earth Systems research now confront is to better understand controls on the terrestrial carbon cycle, and how those controls might be changing with global climate and human land use. The objective was to develop and test a prototype for an innovative modeling framework to couple different types of ecosystem models for land cover change and carbon cycling.

Progress and results
All the original objectives of the project have been met and exceeded. The newest computer modeling framework, based on the concept of a dynamic global vegetation model (DGVM), has been developed and is being extensively tested. The DGVM was developed as a new feature of the NASA-Carnegie-Ames-Stanford Approach (CASA) ecosystem production and trace gas model. It includes calibration of seasonal phenology algorithms using global interannual data sets from the advanced very-high-resolution radiometer (AVHRIR) satellite "greenness" index. In its first tests, the CASA-DGVM correctly predicted the presence of forest classes in about 75 to 95 percent of all cases globally, and grasslands in about 58 percent of all cases. In the process of running the model to steady state, most forest locations showed a rapid progression of transient states, from bare ground to grassland, to grasses with shrub cover, and finally to the forest cover. Changes in biomass, leaf area, primary production, soil organic matter, and other carbon cycle components can be predicted for past, present, and future climates. The effects of hypothetical climate change scenarios are being evaluated.

Significance of the results
This dynamic ecosystem model runs on a regional or global grid structure to enable scientific investigations of transient biosphere interactions with atmospheric chemistry and climate on a planetary scale. This is among the first ecosystem models to include process-oriented controls over global hydrologic, energy, and ecosystem trace gas exchange with a changing land surface. Perhaps most importantly, this DDF-funded research has helped us greatly in writing a successful research proposal, which was selected for the NASA Earth System Science Team on Land Surface Hydrology (under NRA-97-MTPE-12). The newly funded study is titled "Effects of El Nino Climate Variability on Terrestrial Hydrologic Systems." Over the next three years, the DDF-supported model framework will be used to merge historical satellite and climate records from thousands of locations across the globe. The aim is to determine whether regional hydrology has changed significantly during the past decade of El Nino events in both managed agricultural and natural landscape areas. Results will be used to assess how current policy decision making could better incorporate forecasting methods for seasonal-to-interannual climate variability and coupled land surface-hydrologic services, as measured from satellite sensors.

Publications resulting from the study

Potter, Christopher; and Brooks, Vanessa: Global Analysis of Empirical Relationships between Annual Climate and Seasonality of NDVI. Paper presented at the annual meeting of the Ecological Society of America in Albuquerque, New Mexico, Aug. 10–14, 1997. Also in press in Inter. J. Remote Sensing.

Potter, Christopher; and Klooster, Steven: Dynamic Global Vegetation Modeling for Prediction of Biogenic Trace Gas Fluxes. Paper presented at the International Geosphere-Biosphere Program GTCE-LUCC Science Conference in Barcelona, Spain, March 21, 1998. The paper has been submitted, by invitation of IGBP, to Global Ecology and Biogeography Letters.

Keywords
Carbon cycle, Ecosystem modeling, Climate change

Simulations of Mechano-Chemical Deposition and Etching of Atomic Nanostructures on Diamond and Silicon Surfaces

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Deepak Srivastava, MRJ, Inc., Ames Research Center

Other personnel involved
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Objectives of the study
To demonstrate the feasibility of mechanically driven chemical reactions on diamond and silicon surfaces, and study the effect of such chemical pathways on the formation of technologically significant atomic nanostructures on these surfaces. In particular, to investigate the feasibility of scanning probe microscope (SPM) tip assisted nanoscale atomic deposition, etching, and indentation on silicon and diamond surfaces. The new concepts for SPM tips to be investigated in these simulations include bare single-wall carbon nanotubes and chemically modified capped carbon nanotubes. These concepts are investigated because in recent experiments it has been shown that (a) carbon nanotubes can be mounted on silicon cantilever to serve as tips in scanning probe and atomic force microscopy, and (b) carbon nanotube caps as tips can be functionalized with different chemical species. Moreover, with the discovery of these new kinds of atomic scale tips, it should be feasible to test the hypotheses that new classes of reactions are possible if reactant atoms and molecules are mechanically "pushed" into the reaction.

Progress and results
The interaction of a carbon nanotube tip with two chemically modified caps with a single-height-stepped C(001)-(2x1) surface was studied first by performing classical molecular dynamics (MD) simulations. The simulations employed atomic interactions defined by Brenner's model of many-body hydrocarbon potential (ref. 1) implemented in a large-scale simulation code parallelized for the distributed shared memory Origin 2000 supercomputer at NAS. A technical paper on the parallelization of MD code was presented at the IEEE Super Computing conference in 1997 (ref. 2). Two types of chemically modified nanotube tips, with C_2 and $C_6 H_2$ species at the nanotube caps, were considered (refs. 3 and 4). See, for example, figure 1 for the general simulation system configuration. Depending on the surface impact site, the nanotube initial velocity toward the diamond surface and the nanotube tip withdrawal rate of a variety of mechano-chemical reactions have been observed. The $C_6 H_2$ modified tip is able to selectively deposit few C atoms on the diamond surface. However, because of strong nanotube-surface interactions, and thermal vibrational motion of the tip and surface atoms, a variety of nanostructures were deposited with no a priori control over the finally observed products. This result points out the difficulty that may occur in performing the mechano-synthetic reaction proposed recently on the basis of simple mechanistic considerations (ref. 3) and static ab initio calculations (ref. 4). The final C_2 dimer deposition process remains uncontrolled and unpredictable. The C_2 modified tip, on the other hand, is found to bond preferentially to an on-top single radical site. This is in perfect agreement with the results of static ab initio calculations as well (ref. 4). This indeed makes the C_2 modified tip particularly unsuitable for adding a carbon atom on the diamond surface. The surprise of the results came when withdrawal of the reacted C_2 modified tip off the diamond surface was attempted. A selective removal of surface carbon dimer takes place and the robust reaction is repeatable with a variety of initial conditions. The analysis of the results revealed that a C_2 modified tip can be a good "etching" tool. The chemical nature of such a tool is governed mainly by the relative bond strengths of the tip and the surface atoms. If the tip atoms are more strongly bonded to each other than the surface/tip and surface/surface bonds, the nanotube tips can be used as a nanoscale mechanical etching and indentation tool.

This conclusion was general enough that the bare carbon nanotube tip driven etching and indentation of silicon surfaces was tried. These simulations, employing Tersoff's heteroatomic many-body potential for the Si/Ge/C system (ref. 5), also bring a nanotube tip down on a Si(001)(2x1) surface. Two regimes of nanotube tip-surface interactions are considered: in the first scenario, the nanotube tip barely touches the surface, while in the second they are pushed into the surface. The first "gentle" scenario mimics the nanotube-surface chemical reaction

induced by the vertical mechanical manipulation of the nanotube. The second "digging" scenario intends to study the indentation of the surface. In the first regime, depending on the surface impact site, two major outcomes are the selective removal of either a single surface atom or a surface dimer off the silicon surface with minimal disturbance of the surface atoms (fig. 2). Some of the observed transition states are linear and need to be tested with the more accurate quantum generalized tight-binding molecular dynamics (GTBMD) method. In the second scenario, the indentation of the silicon substrate by the nanotube is observed. The nanotube tip is pushed into the surface to make "nanoholes" on the surface. During the "digging" scenario, the nanotube completely preserves its shape (fig. 3). The retraction of the nanotube tip causes the surface and bulk silicon atoms to stick to the tip. At the end of these simulations, the internal structure of the silicon surface is strongly altered, though no apparent hole is formed because of "healing" thermal motion of the bulk surface atoms. The main and "surprising" conclusion is that the nanotube tip cuts and indents a soft silicon surface like a knife cutting a butter slab. A similar indentation on the harder diamond surface results in the distortions and bending of the nanotube tip while the surface remains intact.

The accuracy of these simulations, especially the transition states, with the quantum GTBMD method was tried next, in collaboration with the University of Kentucky. The classical potentials are not suitable for accurate modeling of the transition states because they are local and highly directional. Relatively smaller subspace regions of the transition-state configurations were selected and the quantum GTBMD method was applied on these subspace atoms. In most of the cases of nonlinear transition state, the positions of atoms in the subspace did not change in any substantial manner except for some symmetry lowering distortions caused by the electronic rearrangement. This indicated that the classical many-body Brenner potential can be relied on for structural determinations when such structures consist of diamond surfaces, carbon nanotubes, and benzene rings. The most striking discrepancy is obtained when the connectivity between the nanotube and the surface is through linear chains of carbon or silicon atoms. In the quantum mechanical simulations, the chain is broken, disconnecting the tip from the surface. Simulations were repeated with a silicon surface. In this case also, the linear chain of surface silicon atoms connecting to the nanotube tip is broken. The quantum simulations, however, do not effect the more significant nonlinear transition state etching results, and the results in the indentation scenario where the nanotube penetrates and indents the silicon surface as described above.

Significance of the results

The results of this study achieve the following significant goals: (1) simplistic models of the previously proposed mechano-chemical reactions on silicon and diamond surfaces do not meet the control, stability, and reproducibility criteria because of thermal vibrational motion of the tip and surface atoms; (2) if the nanotube tip atoms are more strongly bonded to each other than the surface atoms, it is possible to use the nanotube tip as a nano-etching and indenting tool; and (3) nanotube tips can be used for making nanoholes on technologically significant silicon surfaces for nanoelectronic, computing, and memory device purposes. The latter two results will be presented for experimentation to the conventional lithography community that is in pursuit of the further miniaturization of silicon-based device technologies.

Publications resulting from the study

Srivastava, D.; and Barnard, S. T.: Molecular Dynamics Simulation of Large Scale Carbon Nanotubes on a Shared Memory Architecture. IEEE, Proc. Super Computing 97, 1997.

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Keywords
Nanotube, Nanolithography, Mechano-chemistry

The Origin and Control of 3-D Phenomena in Nominally 2-D Flows

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Ames Research Center

Objectives of the study

Observation of nominally two-dimensional (2-D) flows (including axisymmetric) reveals an almost universal tendency to develop localized three-dimensional (3-D) phenomena that can dominate the behavior of the flow. Laminar flows are specially susceptible to this tendency. Accurate, experimentally verified computation of this type of behavior has not been demonstrated, for even the simplest of flows; e.g., prediction of transition to turbulent flow is notoriously inaccurate.

The prevailing view is that the final stage of transition involves the onset of 3-D characteristics in 2-D Tollmien–Schlichting (TS) waves that originate from upstream. Considerable effort has been devoted to studying the nonlinear development of TS waves in an effort to identify the origin of the 3-D developments. However, evidence suggests that *other phenomena*, which are *unrelated to TS waves*, may play a potentially *more significant role* in promoting 3-D effects. These phenomena have been largely *overlooked*.

The most clearly evident phenomena are weak *streamwise vortices* (which, for historical reasons, have become known as Klebanoff modes) that introduce spanwise variations in the boundary layer thickness. The objectives of this study are:

1. To gain a fundamental understanding of the underlying physical processes leading to the formation of streamwise vortices downstream of a nominally 2-D attachment-line flow.
2. To explore the role of local pressure gradient as a parameter for controlling the subsequent development of streamwise vortices as the leading-edge flow is blended into a 2-D flat-plate zero pressure gradient (ZPG) Blasius boundary layer.
3. To explore the stability characteristics (e.g., growth rate) of streamwise vortices in a Blasius boundary layer.
4. To explore conditions under which interactions between the vortices and other disturbances (e.g., TS waves) are favorable (e.g., suppression of TS wave growth) or detrimental (e.g., secondary instabilities associated with the vortices).
5. To develop more sophisticated methods for quantifying wind tunnel flow quality.

Progress and results

Experiments have been performed in a dedicated, small-scale, standalone wind tunnel with a highly uniform free stream ($\Delta U/U_1 < 0.05\%$) and an extremely low background disturbance level ($u/U_1 < 0.05\%$). Detailed measurements have been made in a Blasius boundary layer with an exceptionally low background disturbance level ($u/U1 < 0.08\%$ for $Re_x = 0.7 \times 10^6$) and with a high degree of spanwise uniformity.

The wake behind a fine wire has been explored as a means of deliberately introducing a small nonuniformity into the mean flow for the purpose of stimulating the formation of streamwise vortices in the boundary layer. The technique consists of stretching a fine wire normal to the flow and normal to the leading edge some distance upstream. The first set of experiments used two wire diameters, d = 25 μm (0.001 inch) and (0.002 inch), corresponding to Reynolds numbers based on the wire diameter of R_d = 16.7 and R_d = 33.4, respectively. The strength of the wake behind the wires ranges from 1 to 3 percent of the free-stream velocity. Subsequent experiments were performed with the wires located upstream of the wind tunnel contraction.

Interaction of wake behind the wire with the leading edge leads to the formation of a pair of weak streamwise vortices in the boundary layer. This vortex formation mechanism is not understood. Several theoretical hypotheses have been proposed, but they have not been directly tested because of the extremely thin layer in the vicinity of the leading edge. The vortices are associated with local regions of elevated unsteadiness that occur at frequencies very much lower than the instabilities predicted from linear stability theory. The vortices are also associated with a local increase in the thickness of the boundary layer.

The results from the second set of experiments are remarkable because they demonstrate the formation of vortices in the layer, even when the d = 50 μm wire is located 45,000 diameters upstream of the leading edge (i.e., upstream of the contraction) and the strength of the wake is on the order of 0.02 percent of the free-stream velocity.

The effect of these vortices on TS waves was explored by generating 3-D TS waves, using a harmonic point source, and 2-D TS waves using the classical vibrating ribbon technique. The effect of the vortices on the 3-D waves was clear and demonstrative; i.e., the vortices caused a local increase in the TS wave amplitude that is associated with the region of elevated thickness. The effect of the vortices on the 2-D waves was not as clear; i.e., the local increase in amplitude was not as dramatic as for the 3-D waves. However, a spanwise waviness in the shape of the 2-D waves, known from computations to be a precursor to breakdown to turbulence, could be attributed to the vortices.

Although questions remain concerning the mechanism responsible for the formation of the vortices, the seeding of this project with DDF funds has led to NASA funding of an associated project concerned with the effect of flow quality on the results of wind tunnel model testing. This follow-on work is concerned with separation where three-dimensionality is known to arise. The increased thickness of these regions should allow hot-wire measurements to be obtained that may provide some insight into vortex formation mechanisms.

Significance of the results

The association of premature transition to turbulence with free-stream nonuniformity has important implications for wind tunnel model tests and the issue of flow quality. The detrimental effect of the vortices is demonstrated by showing that the growth of TS waves is more rapid in the local region of increased boundary layer thickness between the vortices. The increased growth rate ultimately leads to premature transition to turbulence further downstream.

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Keywords

Streamwise vortices, Tollmien–Schlichting waves, Flow quality

Super Low Thermal Conductivity and Low-Density Ablative Composites

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Objectives of the study
To demonstrate the feasibility of chemically combining aerogel technology with the latest light-weight ceramic ablator material to produce an ultralow thermal conductive in-depth material with high ablative performance at the outer surface. This objective is being accomplished by integrating the aerogel material for its super insulative properties and different light ceramic ablators material for their ablative characteristics.

Background
Ames has been in the forefront of entry technology in both new material development for heat-shield applications and vehicle design. The new lightweight ceramic ablators (LCAs) offer thermal protection against the severe aeroconvective heating and low density, resulting in a low-weight heat shield. However, as mentioned previously, the future missions will utilize the aerobraking technology, which will impose a long heat soak period, requiring a thicker heat shield to keep the vehicle internal structure at a desirable temperature. The outer surface of the heat-shield material needs to have the high thermal performance characteristics, but deeper in the thickness, insulative properties are most important. The inner thickness of the material needs to have a low thermal conductivity (<0.03 W/m-K) to provide insulation, and a low density (0.06 g/cc) to minimize the weight of the heat shield. The problem is developing one material that satisfies all these needs.

The most ideal solution is to develop a new family of monolithic materials that have a very high thermal performance, very low density, and very low thermal conductivity. Monolithic materials in this context would mean materials that are chemically linked and/or hybridized, and preferably not physically bonded. Such a monolithic heat-shield material does not exist. Most materials with density range of 0.08 to 0.05 g/cc, such as aerogels, are so weak that they could not withstand any significant dynamic and thermal loads when exposed to high heating entry conditions. The proposed concept hybridizes the two unique materials, LCAs and aerogels, to form a monolithic material that could withstand the severe external heating environment while maintaining the low in-depth thermal response, as well as having a low overall average density. Thus, future missions to the outer planets using aerobraking technology would not pay a penalty in the thermal protection system by carrying extra heat-shield weight.

Progress and results
Option 1
Ten samples of carbon and silica aerogels were purchased to characterize and obtain the kinetic data for the analytical efforts. Four samples of aerogels, with a density range of 0.03 g/cc, were used in the bonding process to the phenolic impregnated carbon ablator (PICA) material. Four arc-jet models were produced with this technique. The contact surface of the aerogel was primed to activate the reaction sites for the polymerization of the organic resin in the liquid crystal coatings (LCA) process. The carbon or ceramic substrate, with densities of 0.16 to 0.19 g/cc, was physically in contact with the primed surface of the aerogel. The composite was impregnated with phenolic resin and cured to the PICA specifications. During the impregnation process, it is intended to have the aerogels absorb the organic solution, which would gel during the gellation process. The organic gel will serve as the secondary matrix to incase the aerogel and LCA, forming a monolithic material. Consequently, the density of the aerogel will slightly increase.

Characterization of Option 1 Samples
Six samples were produced with the technique described for mechanical and thermal properties evaluation. Figure 1 shows the room temperature thermal conductivity of the virgin PICA, carbon fiberform, and the aerogel-filled version of the two materials. The results showed that there is a decreasing trend in thermal conductivity with an increasing density by loading of the aerogel. This trend does not correspond to the general behavior of the conventional material; that is, the higher the density, the better the conduction path within the material, thus the higher the thermal conductivity. For the aerogel-loaded material, because of its nanoscale nature, the aerogel reduces the mean free path and reduces the radiative heat transfer mechanism within the material.

Figure 2 shows the specific thermal conductivity of the virgin and aerogel-loaded LCA maeterials. This plot magnifies the effect of the aerogel in the LCA fiber matrix. The large thermal resistance of aerogels is

attributed to the high porisity of the gel network, which consists of the interconnected colloidal particles and/or polymeric chains with nanoscale microstructure and is shown in figure 3. The aerogel was loaded in the fiber matrix; however, its presence did not increase the thermal conduction path because of its ultrafine pore size and a very small solid gel network. The overall porosity of the aerogel loaded tile is still 99 percent of the virgin tile; thus there is no net increase in the conduction path. Moreover, the presence of aerogel, because of its gel-network chain-like microstructure, reduces the internal radiation among the fibers matrix, thus increasing the thermal resistance property of the material.

Figure 4 shows the effect of the aerogel loading on the stiffness of the LCA materials. Given the fragility of the virgin aerogel material, the improvement in stiffness in the aerogel-loaded material was not expected. Figure 5 shows that stiffness was improved by 300 percent and 40 percent, respectively, for the aerogel loaded fiberform and PICA.

This improvement indicated that the aerogel manufacturing process further increased the bonding strength of the fiber-fiber within the matrix. This is evident by a large increase in stiffness for the carbon fiberform.

Option 2

Recently, new improvement has been made to the process that would reduce the cost of aerogel to a factor of eight. Traditionally, aerogels were produced with autoclaves that slowly extract the liquid at high temperature and pressure. This process usually takes about a month to produce the desired aerogels. With the new technique, the chemical mixture is injected into a sealed mold, and is heated to the same temperature and pressure of the autoclaves; then the excess liquid is extracted through an injection tube and is recycled for the next batch. The recycling of chemicals and a sealed mold are the main drivers to reduce the manufacturing cost.

The new aerogel technique is somewhat similar to the infiltration process of the LCA. As mentioned previously, LCA materials undergo impregnation of organic solution, gelling cycle, liquid extraction, and a final curing cycle. Four samples were used to demonstrate the new aerogel process, with a minor adjustment in the final liquid extraction and curing cycle.

For example: Three blocks (10 cm × 6 cm × 6 cm) were impregnated with the phenolic resin and placed in the acetone bath. Two of these blocks were supercritically dried in a carbon dioxide environment, and the third one was air dried at 40°C. A scanning electron microscope (SEM) was used to evaluate the difference in the microstructure of the two curing techniques, and the SEM micrographs are shown in figure 6.

Figure 6 shows a distribution of the finer RF particles compared to that of the air dried at 40°C. Thermal and mechanical properties of these two materials are being measured.

Arc-jet testing

In order to evaluate the material ablation characteristics and the thermal response, arc-jet testing is needed. Four models for each manufacturing option were produced for the arc-jet testing. Figure 7 shows a 60-degree cone model geometry used for this test series; it was based on the current geometry of the sample return capsule for both the Stardust and the Mars Sample Return Missions. Thermocouples will be used to obtain the thermal profile from the ablation interface to the back surface of the aerogel. This information will be used in the thermal response model of the LCA/Aerogel material. Recession will be measured to evaluate the effect of the aerogel loading on the ablation characteristic of the PICA and the carbon fiberform. Thermal gravimetric analysis (TGA) will also be performed to determined the ablation, pyrolysis, and virgin zones of each material. This information coupled with the thermocouple data will give a high fidelity in modeling the material response.

Summary

It is shown that the aerogel-loaded LCA have better thermal resistance and mechanical stiffness than the virgin LCA materials. It is due to the ultrafine pore size, and high porosity (up to 99 percent) of the aerogel material. The impregnation of the aerogel increases the overall density of the LCA, but significantly decreases the thermal conductivity and increases the stiffness. SEM was used to examine the difference in microstructure of the aerogel-loaded and virgin material. Different processing techniques were also used to evaluate the effect of the manufacturing option on the microstructure and material properties. It is shown that the supercritically dried samples have finer microstructure than those that were air dried at 40°C. Future work includes the thermal and mechanical properties measurement of these blocks as well as the arc-jet testing of the models to evaluate the material ablation characteristics and thermal response of the LCA/aerogel hybrid material.

Keywords

Aerogel, Ablative materials, Planetary entry, Heat shield, Thermal protection system (TPS)

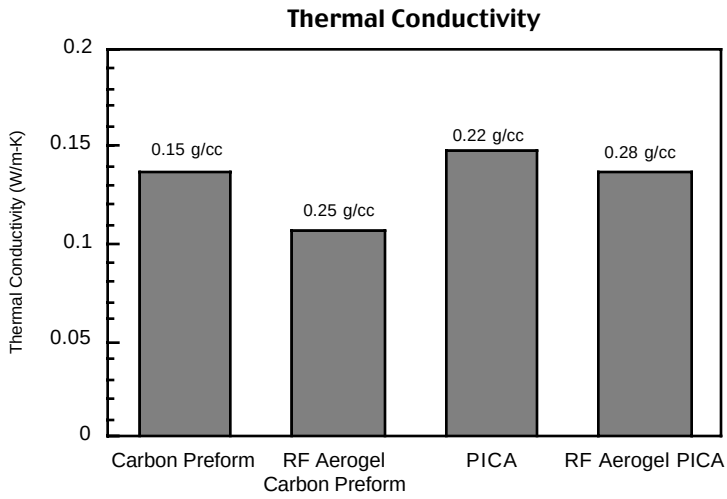

Figure 1. Room temperature thermal conductivity of the virgin and aerogel-loaded LCA materials.

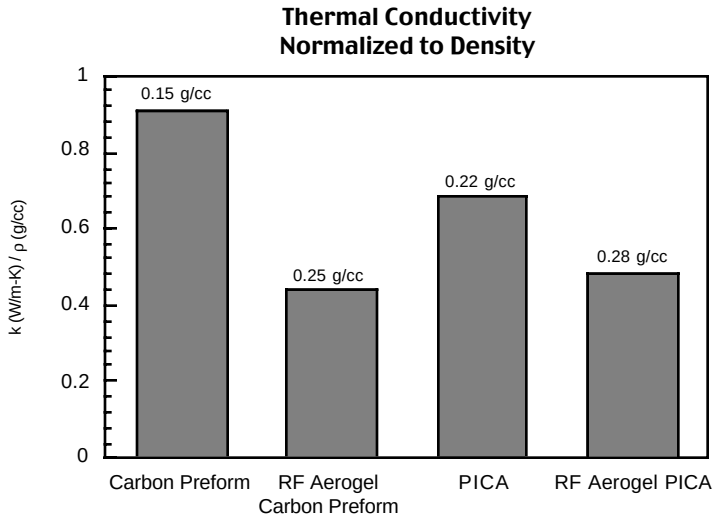

Figure 2. Specific thermal conductivity of the virgin and aerogel-filled LCA.

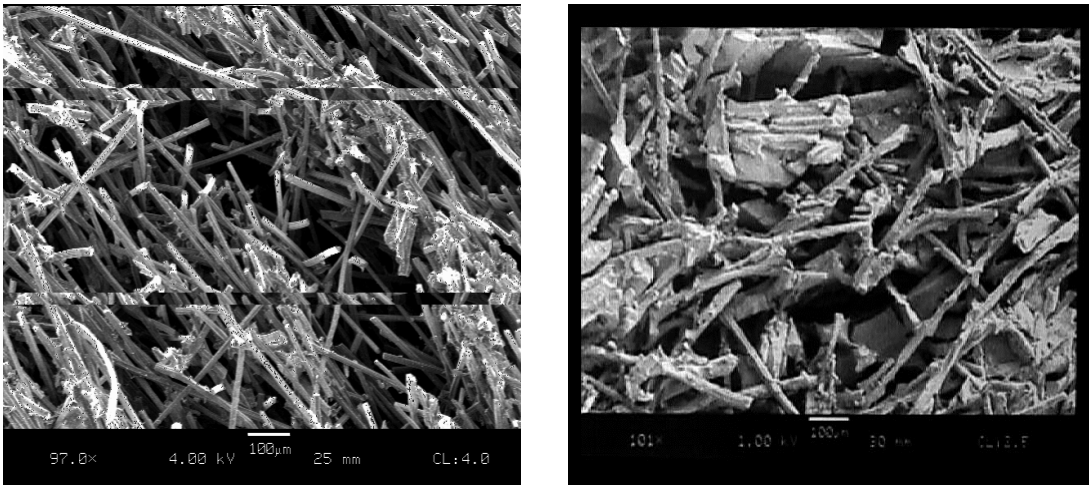

Figure 3. Microstructures of virgin and aerogel-loaded carbon fiberform tiles.

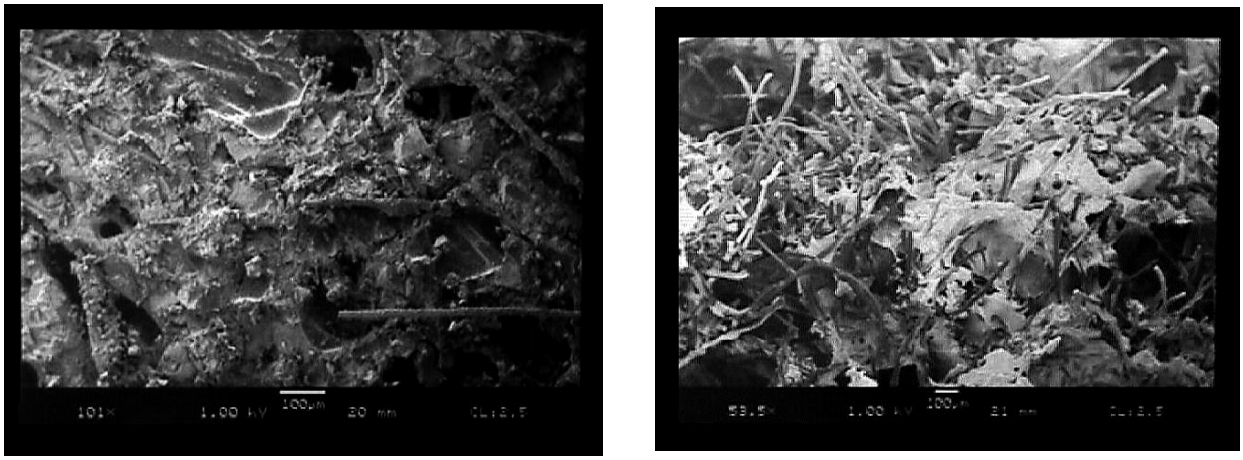

Figure 4. Microstructures of virgin and aerogel-loaded PICA material.

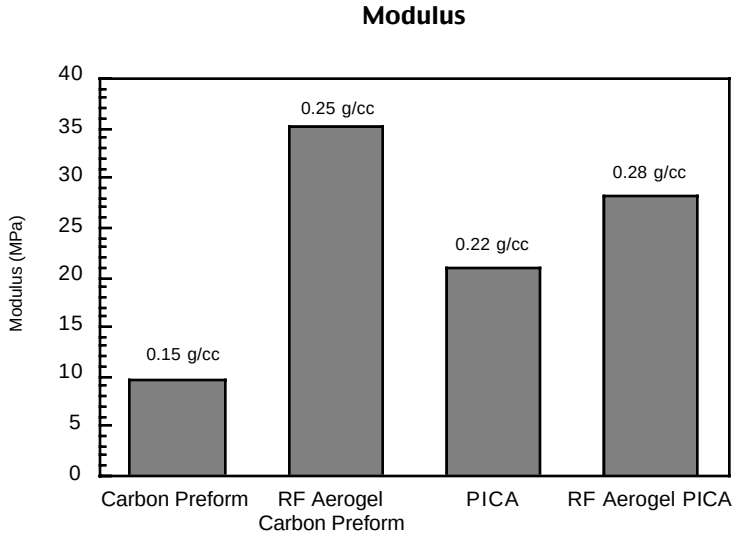

Figure 5. Effect of aerogel loading on the stiffness of virgin and PICA materials.

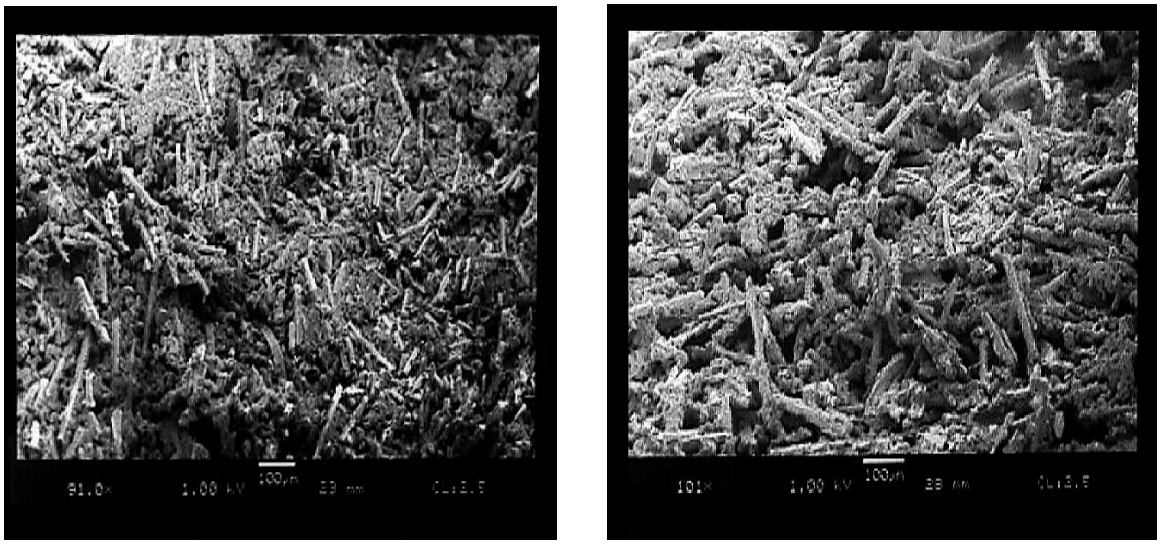

Figure 6. Microstructures of aerogel loaded with two different processes.

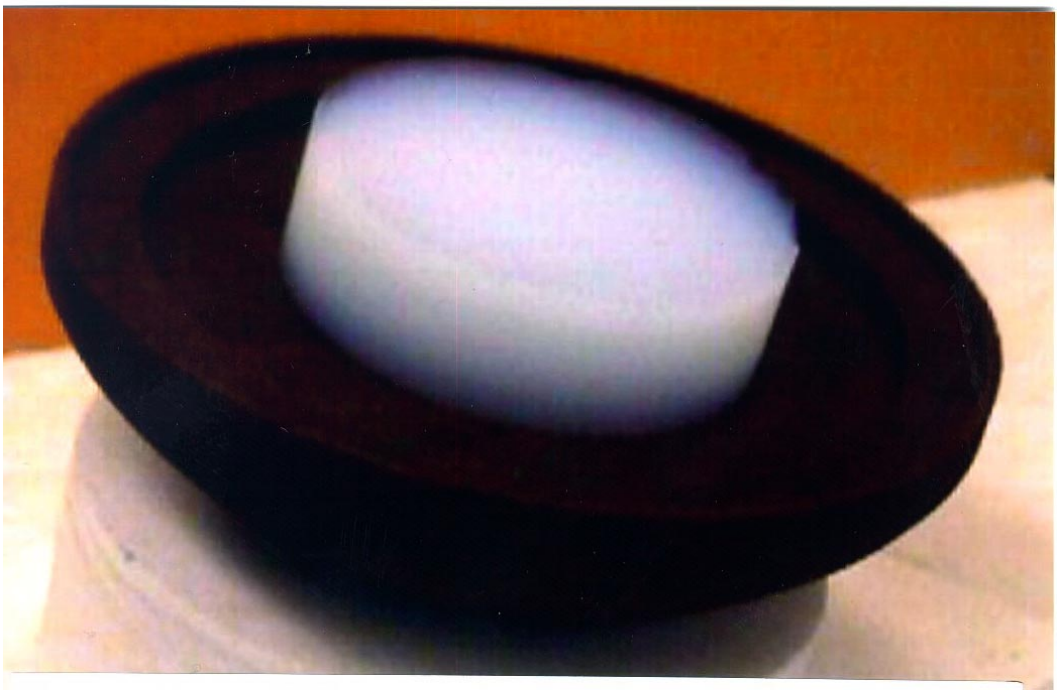

Figure 7. Arc-jet test model planned for late February 1999.

Section 2
Ongoing Reports

Gas-Phase Spectroscopy of Interstellar PAH Analogs

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Objectives of the study
To investigate the potential interrelationship between interstellar polycyclic aromatic hydrocarbons (PAHs) and the carriers of the diffuse interstellar bands (DIBs). The goal is to measure, for the first time, the gas-phase spectra of selected neutral and ionized interstellar PAH analogs to allow a decisive test for these species as potential DIB carriers. These goals can be achieved by using the combined techniques of supersonic free-jet expansion spectroscopy (JES) and cavity ring down absorption spectroscopy (CRDAS).

Progress and results
A feasibility study of the project has been performed and a new experimental setup for the jet supersonic expansion has been designed. The feasibility study consisted of calculating all the optimal experimental conditions (diameter of the nozzle, size and structure of the expansion chamber, appropriate working range for the background, and residual pressure) needed to generate a supersonic jet where the PAH molecules are vibrationally and rotationally cold (10 and 100 K, respectively) and fully isolated from each other. These conditions are essential to simulate the physical conditions known to exist in the diffuse interstellar medium and to remove the spectral congestion observed/expected with such large polyatomic molecules when probed using more classical analytical techniques. The experimental setup required for such a study consists of a high-pressure gas reservoir connected to a pulsed nozzle. The pulsed beam is then expanded in a vacuum chamber coupled to a cavity ring down chamber. The vacuum hardware (expansion chamber and precision manipulators), the pulsed nozzle, and the pumping stations have been either home built and/or ordered.

Various experts in CRDAS techniques have been approached to establish a collaboration for the feasibility studies of cavity ring down measurements. This effort has resulted in a collaboration with three research groups at the forefront of the CRDAS research: the Los Gatos Research Institute (headed by the person who first developed CRDAS techniques), the Chemistry Department of the University of Berkeley, and the Physics Department of the University of Grenoble (France).

The supersonic jet expansion chamber has been coupled with a cavity ring down chamber and the ultraviolet, visible, and near-infrared spectra of a few selected, free, molecular PAHs have been measured in their neutral and ionized forms. The result was the measurement of the first-ever successful measurement of the vibronic transitions of a PAH cation in the gas phase. With the feasibility studies successfully demonstrated, now the JES-CRDAS system will be set up in the Ames Astrochemistry Laboratory.

Significance of the results
The results obtained so far are a real breakthrough in astrophysics as well as in molecular spectroscopy. For the first time, the absorption spectrum of a PAH cation has been measured under conditions that mimic entirely the interstellar environments [the molecular ions are isolated, vibrationally and rotationally cold (10–100 K range) and in the gas phase]. It is now possible to compare astronomical spectra directly with the laboratory data. The new experimental facility that will result from this project will provide the Ames Astrochemistry Laboratory with a unique research tool.

Publications resulting from the study
The results of the feasibility studies have been presented in an article to Physical Review Letters (presenting the first gas-phase spectrum of a PAH cation and the comparison with the diffuse interstellar bands) and in a Small Business Innovative Research (SBIR) report to ARC.

Keywords
Astrobiology and prebiotic aromatic molecules and ions, Astrochemistry, Diffuse interstellar bands, Supersonic jet electronic spectroscopy (SJES), Cavity ring down absorption spectroscopy (CRDAS), Polycyclic aromatic hydrocarbons (PAHs), Environmental studies

Development of a Tethered-Glider Probe-Positioning System for Use in Wind Tunnel Testing

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Objectives of the study
To demonstrate the feasibility of using a tethered glider with an onboard, miniature, data-acquisition system and a flight-control system as a minimally intrusive, probe-positioning system in a large-scale wind tunnel environment.

Progress and results
Design and fabrication of the first glider airframe has been completed. The airframe is an entirely composite structure. Male plugs were machined for the various airframe components and used to construct the female molds for the parts. Fabrication of the molds for the composite airframe account for approximately 80 percent of the cost of fabricating the first glider airframe. Additional glider airframes can be produced at a fraction of the cost of the first one, an important feature in the event the glider becomes damaged during testing. Control surfaces for the glider include an all-movable canard, full-span ailerons, and rudders on the tip sails. Actuators and linkages for the control surfaces were installed using conventional radio-controlled (RC) model airplane techniques. Access hatches were installed in several places on the airframe to allow installation of the data-acquisition and digital flight-control systems as well as the batteries required for powering those systems. Attachment points were included for mounting the systems and batteries internal to the glider airframe.

The low-order potential flow panel code PMARC was used to establish the stability derivatives for the flight-control system. For the purpose of demonstrating the feasibility of the tethered glider probe-positioning system, the flight-control system will be restricted to first-order linear flight-control laws. The flight-control system consists of a PC/104 CPU and analog to digital converter (ADC) unit and commercially available servomotors. The servomotors are driven by the parallel interface of the PC/104 flight computer. The flight-control software is currently being developed. The glider can also be flown under manual flight control using a commercial radio control and bypassing the onboard flight-control system. The manual system is intended as a backup to the flight-control system and also for outdoor checkout flights of the glider. A servointerface, which includes an emergency manual-control override, has been developed, fabricated, and tested. This interface provides the connections between the servomotors, an RC receiver, and the digital flight-control system.

The first outdoor flight test of the glider was completed late in fiscal year 1998. The glider was flown under manual control as an initial checkout of the airframe and control surfaces. The data-acquisition and flight-control systems, batteries, and solid-state gyroscopes and linear accelerometers were not installed for the initial flight as a precaution to avoid risking damage to these components and to keep the wing loading to a minimum. The glider was successfully flown using a conventional radio control. Remaining tasks include an outdoor flight test of the glider using the onboard flight-control system and the final demonstration of the tethered glider probe-positioning system in the wind tunnel.

Significance of the results
The initial aerodynamic checkout of the glider airframe has been completed. The data-acquisition and flight-control systems, solid-state gyroscopes, and batteries are all ready to be installed in the glider. Once feasibility of the tethered glider probe-positioning system has been demonstrated in a wind tunnel, the system will provide a new tool for conducting flow-field surveys in large wind tunnels. Enhancements such as a propulsion system or miniature charged coupled device (CCD) cameras will further expand the capabilities of the system. The tethered-glider probe-positioning system also has potential applications in flight testing and other areas.

Keywords
Flow surveys, Unmanned autonomous vehicle, UAV, Data acquisition

Where Are the Hidden Supernovae?

Investigator(s)
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Objectives of the study
To determine whether there are supernovae hidden from view at optical wavelengths in the cores of starburst galaxies and to measure how often they occur. The supernova rate in galactic nuclei, emphasizing starburst nuclei, will be measured by using a two-dimensional midinfrared array camera to observe a large enough sample of infrared luminous galaxies over a two-year period at the wavelength of the CoII emission line, 10.52 μm, to set meaningful upper limits to the rate of hidden supernovae. This method has several advantages: (1) the CoII line is extremely strong and broad [full width at half maximum (FWHM) ≈ 3000 km/sec]; (2) the CoII line occurs only in supernovae; (3) there is little trouble from obscuration by dust; and (4) the line remains strong for at least six months, a timescale long enough that with observations scheduled every four months all recent supernovae should be seen.

Progress and results
A 256×256 HgCdTe array and a set of drive electronics have been purchased. The array will be installed in an existing infrared camera dewar after checkout of the electronics. The initial laboratory checkout will occur, followed by verification of performance on a telescope at Lick Observatory. Initial observations of galaxies from the Wyoming Infrared Telescope should occur in late winter or early spring.

Keywords
Infrared arrays, Supernovae

Graphics Software Architectures for True Three-Dimensional High-Resolution Volumetric Displays

Investigator(s)

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Objectives of the study

Inherently three-dimensional displays ("volume displays"), which fill physical three-dimensional space with truly three-dimensional images, recently have been developed. These volume displays use a variety of technologies ranging from moving arrays of lights to intersecting lasers. Volume displays present truly three-dimensional images, which contain all the correct depth cues simultaneously for multiple viewers. By providing high-quality three-dimensional images to multiple viewers, volume displays support collaborative computer-based design and engineering. Such collaboration is critical in several NASA missions such as spacecraft and aircraft design, operations, and the visualization of scientific data.

Current approaches to computer graphics, based on raster methods and frame buffers, are not well suited for volume displays. The purpose of the research is to develop a hybrid raster and vector graphics approach, referred to as a "sparse raster." In this approach, graphical primitives such as polygons embedded in three dimensions would be converted into points and lines using three-dimensional generalizations of conventional raster, which would then be rendered in the volume display using three-dimensional vector techniques. The sparse raster approach sends to the volume display only the data to be drawn rather than a frame buffer that may be mostly empty. The research will result in a simple graphics library that renders three-dimensional graphical primitives using the sparse raster approach. This graphics library would support points, lines, and polygonal surfaces, and would allow simple monochromatic shading algorithms such as Gouraud shading and simple lighting. This library would be used to implement simple demonstration programs using a volume display, including an interactive scientific visualization application.

Progress and results

Preliminary design of the sparse raster approach has been done. The purchase of the volume display system to test this design has, however, encountered procurement difficulties and it was not possible to acquire the volume display in FY98. The procurement has been re-initiated and delivery is expected in 2Q FY99.

Keywords

Three-dimensional display, Virtual reality, Scientific visualization

Self-Contained Oculomotor Tracking System (SCOTS) to Study Gaze Control in Humans during Self-Locomotion

Investigator(s)

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Objectives of the study

To fabricate and test a portable, first-generation SCOTS to measure the movements of both the eyes and the head during a variety of behavioral situations such as walking, running, standing up, and bending over. As a part of the SCOTS development, software will be written that will enable the user to easily acquire data and download the stored data. The system will make use of currently available technologies to minimize development costs.

Progress and results

The accomplishments thus far involve acquiring the necessary components, some of which were immediately available, whereas others had to be manufactured (i.e., the nC52™ System and the microguide eye tracking system).

The modular computer utilizes the nC52™ System provided by Adaptive Systems, Inc. The nC52™ engineering kit consists of user-defined modules mounted on a carrier board. At the core of the system is the nC52™ 5_x86 Processor Module (Advanced Micro Devices 5_x86 chip) configured with 32 MB of DRAM. The processor runs at 133 MHz to give a 105.6-MBps burst bus at 33 MHz. The carrier board provides for system management, VGA control, and input/output (I/O), and, therefore, is equipped with industry-standard connections for a mouse (PS2 or serial), keyboard, VGA port, parallel port, COM1 and COM2 ports, IDE connector for a hard drive, a connection for a 3 1/2-inch floppy drive, and a PCMCIA module based on the Cirrus Logic CL-PD6722 Host Adapter, which provides for two PCMCIA sockets.

A monitor, PS2 mouse, keyboard , and a 540-MB hard drive were connected to the carrier board. A regulated power supply was set up to provide 12-V power to the board. Once the peripheral devices were connected, the BIOS for the 5_x86 processor was configured. The serial and parallel ports were tested for proper functioning. The system provides for two PCMCIA sockets. Socket A contains the analog-to-digital (A/D) card (Keithley) that will be used to acquire the horizontal and vertical eye movement signals. Socket B contains a 110-MB Flash memory card (SanDisk Corp.).

Preliminary tests of the Microguide eye tracker were done using the PC and data-acquisition setup associated with the 30-Ft Linear Sled laboratory at the Vestibular Research Facility. The Microguide system provides for binocular infrared oculography and is capable of measuring horizontal and vertical eye movements with a resolution of about 0.1°; however, further tests will be conducted to determine the true resolution of the horizontal and vertical channels. It will also be necessary to determine the range over which the signal is linear.

The function of the Altera chip will be to provide the interface between the six digital accelerometers and the CPU. The Altera chip will 1) provide the clock frequency for all the accelerometers, 2) count the pulses from the accelerometers, 3) set the acquisition rate, 4) perform the accelerometer calibration, 5) buffer the data to the CPU, 6) provide digital I/O for LEDs, 7) provide user-definable buzzer tones for menu selections, and 8) provide a ready signal to the CPU for data acquisition. The work involving the Altera chip is being handled at the Palo Alto VA Hospital. Development of the capabilities of the Altera chip is nearly complete.

Significance of the results

Assembly of the SCOTS has progressed well. The next step will be to acquire data through the A/D card using PCMCIA socket A and write the data initially to the hard drive and later to the Flash card in PCMCIA socket B. Once the Altera chip is programmed, it will be incorporated into the system and the program that will execute the data acquisition will be written. The final phase of the project will be to return the development system to Adaptive Systems, Inc., so that they can manufacture the finished board.

Keywords

Gaze control, Portable eye tracker

Vestibular Galvanic Stimulation as a Countermeasure for Muscle Atrophy

Investigator(s)

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Other personnel involved

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Objectives of the study

Muscle atrophy, along with the accompanying structural and functional deficits in the musculoskeletal and neuromuscular systems, is a serious consequence of unloading because of the absence of gravity in space flight. This research tests the efficacy of noninvasive vestibular galvanic stimulation (VGS) in preventing muscle atrophy due to unloading. It is hypothesized that VGS will modify excitability ("change the bias") of motoneurons linked specifically to antigravity muscles, leading to increased excitability and tone in those muscles. This increase in excitability and/or tone should prevent or ameliorate the muscle atrophy due to unloading, without the need for time-consuming exercise regimens or for drugs. Noninvasive galvanic stimulation of the vestibular system via electrodes placed on the mastoid process is widely used clinically in humans for diagnosis of vestibular system disorders. This research will determine whether noninvasive VGS will prevent or minimize muscle atrophy induced by unloading in rats, using the hind-limb suspension model.

Progress and results

The importance of vestibular influence on hindlimb neuromuscular system in the rodent has been confirmed using two different techniques. In the first study, activity in the gravity-sensing portion of the vestibular system was increased during 30 minutes of VGS to confirm that this stimulation does influence spinal motoneurons that control antigravity muscles. Results of this study, in which c-fos was used to identify neural areas activated by the stimulation, show that VGS does influence motoneurons projecting to hind-limb muscles, thus increasing the probability that VGS will have a therapeutic effect on hind-limb muscle atrophy due to unloading. In the second study, the effect of damaging the gravity-sensing portion of the vestibular system on the reflex response of hind-limb muscles to sudden unloading or free fall was examined. In these animals, the free-fall response in hind-limb muscles was absent or greatly attenuated compared with normal animals, thus again confirming the influence of the vestibular inputs on antigravity muscles.

The next phase of the project involved the development and testing of different types of noninvasive electrodes for providing bilateral bipolar VGS to the rat. Numerous designs for these electrodes were assessed, several of which appeared to work (responses elicited in the hind limb) in lightly anesthetized animals, but not in the awake, moving animal because of an inability to keep the electrodes firmly in place. The decision was thus made to use subcutaneously implanted electrodes in the tests of effectiveness of VGS in preventing muscle atrophy. If VGS proves effective, then additional time could be spent in further development of noninvasive electrodes. However, since the ultimate use of this technique will be with humans, for which VGS techniques with noninvasive electrodes are used routinely, it is probably unnecessary to continue the development of noninvasive techniques for the rat.

Significance of the results

The studies completed thus far have confirmed that the vestibular system, and in particular the gravity-sensing portion of this system, can influence the hind-limb neuromuscular system. Thus, the hypothesis upon which this project is based has been upheld, making the project much more likely to succeed. By moving to the use of implanted electrodes and ignoring the technical difficulties with noninvasive electrodes in the rat, the concept validation phase of this project can be completed relatively rapidly. Since noninvasive VGS electrodes and stimulus protocols already exist for use in humans (as part of vestibular diagnostic testing), once the efficacy of VGS as a countermeasure for muscle atrophy in the rat is determined, implementation and testing of this countermeasure in humans will be relatively straightforward.

Publications resulting from the study

Polyakov, I. V.; Kaufman, G. D.; Daunton, N. G.; Fox, R. A.; and Perachio, A. A.:. The Effect of Galvanic Translabyrinthine Utricular Stimulation on Fos Expression in the Gerbil Brain and Spinal Cord. Paper presented at 27th Annual Meeting of the Society for Neuroscience, New Orleans, La., Oct. 25–30, 1997; Society for Neuroscience Abstracts, vol. 23, 1997, p. 1291.

Daunton, N.; Fox, R.; Corcoran, M.; Taber, P.; and Wu, L.: Suppression of Otolith-Spinal Reflex by Chronic Hypergravity Exposure and Streptomycin Treatment. Paper presented at 27th Annual Meeting of the Society for Neuroscience, New Orleans, La., Oct. 25–30, 1997; Society for Neuroscience Abstracts, vol. 23, 1997, p. 754.

Keywords

Gravity, Muscle, Vestibular, Unloading, Muscle atrophy, Vestibular galvanic stimulation, Rat

Prospective Memory in Dynamic Environments

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Objectives of the study

Prospective memory is memory for intentions that must be deferred for action at a later time—remembering to remember. In aviation operations, forgetting to perform an intended action can have disastrous consequences. Until recently, only a few laboratory studies have addressed prospective memory, and these few studies used tasks quite dissimilar to the dynamic, visual-spatial tasks of air traffic controllers and pilots.

Prospective memory may represent a special, unique form of memory distinct from retrospective memory (which has been studied extensively). Alternatively, it may represent a blend of retrieval processes shared in common with retrospective memory and control/attentional mechanisms that set task priorities and execute plans.

In this DDF project, a laboratory paradigm in which a prospective task is integrated meaningfully into an ongoing dynamic visual/spatial task has been designed. This paradigm is thought to capture some relevant aspects of the tasks of controllers working at radar displays. The goals are to:

1. Determine how prospective memory is affected by factors such as working memory load of the ongoing task, how long the intention must be held in memory, and environmental cues that may support retrieval of the intention.
2. Compare results in the paradigm to those from previous studies.
3. Determine whether the present results can be accounted for in terms of mechanisms already well-elucidated for attentional processes and retrospective memory retrieval.

Progress and results

The rather complex programming required for this type of paradigm and the first experiment have been completed, and the second experiment is almost finished.

Figure 1 shows the visual display experimental subjects used while performing the experimental task. A series of targets (airplane symbols) follow a rectangular path with eight waypoints and three alternate waypoints. The subjects' task is to click on each target while it is in the window approaching each waypoint. Normally, each target is directed on to the waypoint it is approaching; however, in a few instances the subject must direct the target to an alternate waypoint. In these instances, the subjects are given this instruction in advance and must remember this instruction for a period (one, three, or five minutes) that is manipulated experimentally. The subjects' workload is also manipulated by varying the number of targets they must control. The primary dependent variable is the percent of instructions to divert to an alternate waypoint (the prospective task) subjects follow correctly.

Figure 2 shows data from the 28 subjects in the first experiment. The number of errors subjects made increased with workload and with delay (time the prospective instructions must be remembered). Workload and delay interacted such that the effect of workload was diminished at the longest delay (five minutes).

It is suspected that subjects use rehearsal to maintain the instructions in working memory, and perhaps rehearsal is more effective for the two shorter delays. Also, rehearsal may be more effective in the lower-workload condition. To investigate these issues, in the second experiment the subjects perform the same tasks as before and at the same time perform a secondary, auditory task (shadowing) known to prevent subvocal rehearsal.

After analyzing the results of the second experiment, the remaining experiments will be designed.

Significance of the results

Although the project is not yet complete, two conclusions can be tentatively drawn:

1. The factors that appear to govern successful retrieval and execution of this prospective memory task seem to be similar to the factors that govern memory retrieval in general.

2. Retrieval of the prospective instruction at five minutes operates differently than retrieval at shorter intervals. This finding may reflect different uses of rehearsal and working memory.

When the experiments are finished, practical ways in which individuals can reduce their vulnerability to forgetting deferred intentions should be obvious.

Publications resulting from the study

When these experiments are finished, the results will be published in an experimental psychology research journal.

Keywords

Prospective memory, Task switching, Working memory

Martian Fossils in the ALH84001 Meteorite: An Independent Assessment of the Evidence

Investigator(s)
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Objectives of the study
To reevaluate the biogenicity of microfossil-like features found in Martian meteorite ALH84001, based on detailed comparisons to terrestrial analogs of known origin. To achieve this goal: 1) Nutrient limitation methods were used to derive an empirically based estimate for the minimal cell sizes achieved by four species of heterotrophic microbes isolated from hydrothermal environments. (Hydrothermal environments are considered to be a good analog for ALH84001 carbonates.) 2) A reevaluation of features commonly found in terrestrial rocks that have been broadly referred to as "nanobacteria" was begun. 3) In situ fossilization studies were begun to document the preservation potential of small bacteria, particularly those found in hydrothermal environments. 4) Mineralogical and microstructural comparisons of nanometer-scale putative nanometer-scale biogenic features in the ALH84001 meteorite and in terrestrial analog materials were made.

Progress and results
The following was accomplished in 1998: 1) Four species of thermophylic heterotrophic bacteria typical of environments that have been postulated for carbonates of the Mars meteorite were successfully isolated and cultured. 2) Nutrient limitation experiments were used to evaluate the lower size limit for these species under conditions of starvation typical of deep subsurface environments (nutrient levels of 1% and 0.1%) and earlier experiments to evaluate the effects of prolonged starvation were continued. 3) Critical Point Drying Methods and Scanning Electron Microscopy were used to characterize experimental cultures and obtain preliminary morphometric data on cell size.

Significance of the results
Our culture-based analog studies are important for providing an experimental framework for testing hypotheses about what controls the lower size limit of living cells and for establishing an empirical lower size limit for life to which theoretical arguments can be compared. In addition, in vitro biomineralization and fossilization studies are important for establishing a baseline for comparing nanoscale morphological features observed in the ALH84001 meteorite and for ancient rocks on Earth. The establishment of reliable criteria for recognizing the biogenicity of morphological structures preserved in ancient rocks is extremely important for improving our accessibility to the early history of the Earth's biosphere, and is also essential in exploring for past life on Mars when samples are returned to Earth early next century.

Keywords
Mars, Meteorite, ALH84001, Exopaleontology, Biogenicity, Fossils

A Technique and Strategy for Probing the Organic Signature of mm–cm Sized Cometary Debris during a Meteor Storm

Investigator(s)
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Peter Jenniskens, SETI Institute, Ames Research Center

Objectives of the study
To measure molecular bands and atomic lines in the near-infrared (near-IR) emission spectra of meteors, specifically during the Leonid shower of November 1998 and 1999 when a meteor storm is expected and the instrument can be operated under dry conditions at high altitude as part of NASA's Leonid Multi-Instrument Aircraft Campaign. In particular, to detect molecular bands that trace the kinetic conditions in the meteor path and identify molecular products of meteor ablation and chemistry of biogenic elements accreted into the Earth's atmosphere. The instrument concept is a near-IR slitless spectrograph, which consists of a high-dispersion grating (max. 600 l/mm) in front of a lens with long focal length (300 mm) and low f number (f2.8), an order filter (>550 nm), and a detector.

Progress and results
Two detection techniques have been assembled and tested. One consisted of an X1332 image intensifier and camcorder. This system, with a low-dispersion 230 l/mm grating, successfully detected one meteor emission spectrum of a Perseid meteor during a test on August 12. That spectrum for the first time showed resolved molecular emission bands of N_2, N_2^+, and O_2. Band shape changes with changing excitation conditions were observed.

Disadvantages of such an intensified system were identified: background irregularities due to the phosphor screen filmed by the camcorder, which could not be fully removed, and the rapid decay of sensitivity above 800 nm, as well as the low dynamic range of the system.

To improve on this result, a back-illuminated charged coupled device (CCD) camera was used as a detector instead. The CCD camera has a high dynamic range, is sensitive up to 1060 nm, and has a good flatfield. To take full advantage of the sensitivity of the device, a system with relatively long readout time was used. The long readout time causes dead time during recording of the sky, but that should not be a problem when meteor rates are high. Hence, software features were developed to provide continuous recording of images and storage of a given frame when a meteor spectrum is detected. The system with a 600 l/mm grating was tested during a brief test flight for multiple instruments in Broomfield, Colo., on October 1, on board the National Center for Atmospheric Research (NCAR) Electra aircraft. Continuum spectra of stars as faint as magnitude +3 were detected. No meteor spectrum was recorded at that time.

Significance of the results
This instrument awaits application during the November 1998 Leonid meteor return, when meteor rates will be high. Further improvements are expected as a result of the November flight. The August 12 and October 1 tests have demonstrated that the system is better than previous meteor spectrographs and can detect molecular bands with sufficient resolution to resolve the bands for quantitative analysis.

Keywords
Meteor spectroscopy, Remote sensing, Imaging spectrometers

A Modeling Approach to Global Land Surface Monitoring with Low-Resolution Satellite Imagery

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Other personnel involved
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Objectives of the study
A new approach to developing accurate estimates of global extents of land use/land cover types with maps derived from satellite imagery is being developed. This objective is being accomplished by: 1) testing models of the size distribution of patches of specific cover types as mapped with imagery of relatively fine spatial resolution; and 2) developing numerical procedures for estimating total area of these cover types with low-resolution satellite imagery that incorporates models of size distribution and effects of pixelation.

Progress and results
Landsat Multispectral Scanner (MSS) maps of recent fires in Brazilian tropical savanna and synthetic aperture radar (SAR) maps of open water in Alaskan and Siberian tundra were used to assess the accuracy of areal estimates at various spatial resolutions, the effects of resolution on the distribution of observed scar and pond sizes, and test methods for improving estimates based on models of size distribution.

Simulated moderate resolution imaging spectrometer (MODIS) maps of recent fires were created from Landsat MSS maps. Areal estimates based on the simulated MODIS differed from Landsat by as much as 50 percent. The MODIS estimates were close to Landsat estimates if there was a small bias in processing toward commission; that is, if pixels with somewhat less than half of the target cover type were labeled as scar or pond.

Fire scar and pond sizes, and also simulated data, were assessed with graphic and quantitative techniques. The observed distributions were apparently log-normal on imagery of moderate (~100 m) and coarse (simulated 250 m) resolution, but the actual distribution is probably Pareto (i.e., a power distribution). Software for adjusting estimates based on lognormal and Pareto distribution models was developed. Initial tests show that MODIS estimates can be adjusted to reduce the difference between MSS and MODIS by more than 50 percent.

Significance of the results
The distributions of sizes of burn scars in tropical savannas and ponds in Arctic tundra indicate the important contribution of small patches, with sizes similar to or smaller than the pixels sizes of satellite imagery used for regional and global monitoring, to total area. Improved areal estimates will lead to better estimates of greenhouse gas production and effects on the energy balance between the Earth's surface and the atmospheres that are associated with biomass burning and high-latitude wetlands.

Publications resulting from the study

Hlavka, C. A.; and Livingston, G. P.: Statistical Models of Fragmented Land Cover and the Effect of Coarse Spatial Resolution on the Estimation of Area with Satellite Sensor Imagery. International J. Remote Sensing, vol. 18, no. 10, 1997, pp. 2253–2259.

Hlavka, C. A.: Statistical Models of Landscape Pattern and the Effects of Coarse Spatial Resolution on Estimation of Area with Satellite Imagery. In: Quantifying Spatial Uncertainty in Natural Resources: Theory and Applications for GIS and Remote Sensing, H. T. Mowrer and R. G. Congalton, eds., Ann Arbor Press, Chelsea, Michigan, in press, 1998.

Keywords
Satellite imagery, Spatial resolution, Areal estimates

Spectroscopic Studies of Mass-Selected Ions and the Evolution of Carbon-Bearing Molecules in the Galaxy

Investigator(s)
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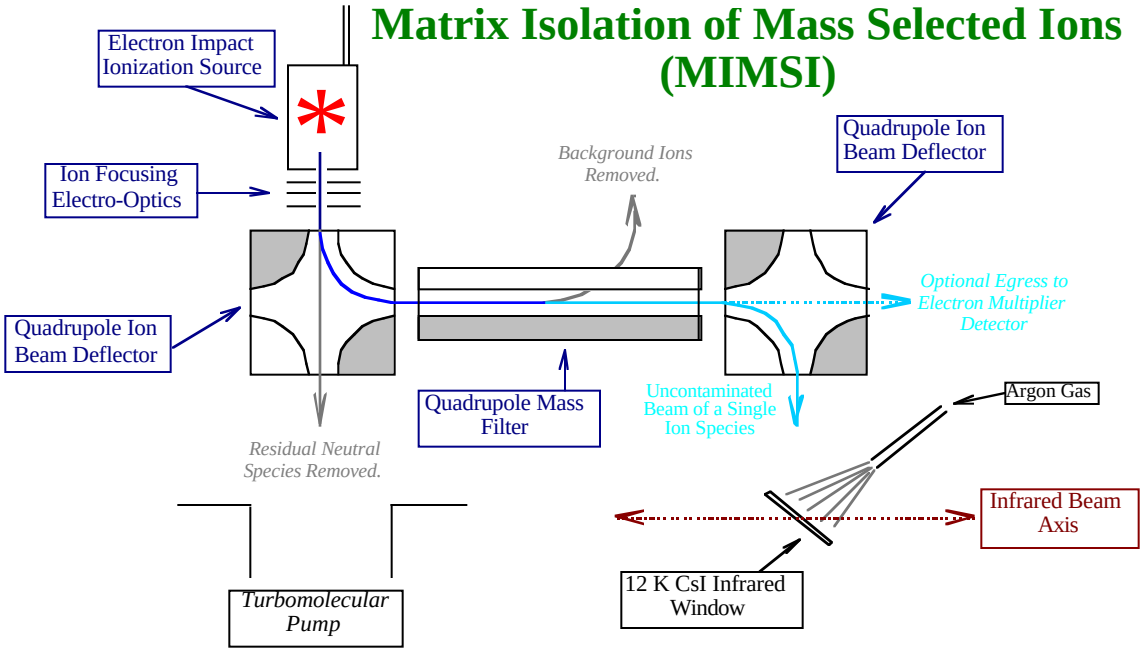
Other personnel involved
Robert Walker, Ames Research Center

Objectives of the study
In recent years, it has become clear that polycyclic aromatic hydrocarbons (PAHs) and related materials are prominent at all stages of the life cycle of matter in the interstellar medium. As a consequence, not only do these species hold enormous potential as probes of the interstellar medium, but they also represent the single largest source of prebiotic organic carbon in evolving planetary systems. Unfortunately, the highly reactive, transient nature of the PAH species, which routinely thrive under interstellar conditions, makes it notoriously difficult to generate and study all but the simplest analogs in the terrestrial laboratory. The goal of this project is to greatly increase and diversify the inventory of PAH-related transient species that can be studied spectroscopically in the laboratory. This goal will be accomplished through the development of a unique, new gas phase ion source capable of producing and isolating pure, mass-selected ions that can then be trapped in an inert solid matrix and probed spectroscopically.

Progress and results
A detailed design for the mass-selected ion source has been generated, and the ion production/mass-selection electronics have been purchased. A schematic of the system is shown in the figure.

Significance of the results
The spectroscopic measurements of ionized PAH-related molecular species facilitated by this project will allow the full exploitation of those species as interstellar probes, and reveal the step-by-step evolution of carbon-bearing molecules from their birth in circumstellar shells, through their maturation in the interstellar medium, to their incorporation into planetary systems.

Keywords
Ionized polycyclic aromatic hydrocarbons, Infrared spectroscopy of molecular ions, Life cycle of interstellar organic molecules



Application of Unsteady CFD and Sensorless Adaptive Control for the Development of a Long-Term Left Ventricular Assist Device (LVAD)

Investigator(s)
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Cetin Kiris, MCAT Institute, Ames Research Center

Other personnel involved
Primary responsibilities of participating organizations are as follows:

NASA/ARC: Develop and implement unsteady CFD procedures for the analysis of various operating conditions.

NASA/JSC: Responsible for the entire system design, including power source and controller.

MicroMed and Baylor College of Medicine: Perform clinical testing and provide test data. Responsible for all implant decisions and implantation.

Objectives of the study
To develop a procedure for designing a long-term or permanent ventricular assist device (VAD) by implementing adaptive control in conjunction with numerical simulations of time-varying pulsatile flow.

Progress and results
Mechanical blood pumping devices are in demand as a life-support system to assist ailing hearts. Currently, the commercially available circulatory support involves large, complex, and expensive pulsatile devices. These diaphragm-type or cable-driven devices require large, external support equipment, resulting in little or no patient mobility.

In 1989, NASA/Johnson Space Flight Center (JSC) began a joint project with the DeBakey Heart Center of the Baylor College of Medicine in Houston, Texas, to develop a new, implantable total VAD (NASA/DeBakey VAD) complete with a control electronics package. This VAD is based on a fast-rotating axial pump using magnetic propulsion, requiring a minimum number of moving parts. To make it implantable, the device is to be made as small as possible, a stipulation that requires a very high rotational speed.

Depending on the usage, the requirements for VAD vary; they can be classified by the following three levels of operations:

Level 1: Two-Day Pump
This pump is used mainly after cardiovascular pulmonary bypass surgery. For this application, the hemolysis must be kept at a low level. Approximately 350,000 surgical procedures are being performed each year.

Level 2: Two-Week Pump
This pump is used mainly for postsurgical heart failure and emergency cases. In addition to the low hemolysis, low blood clotting is required for this application. Approximately 25,000 patients need this treatment each year.

Level 3: Long-Term Pump
The long-term device is needed as a bridge to transplant or as a permanent assist device. For this purpose, sustained operation of five years or longer is desired. Each year approximately 60,000 patients need long-term support, while only 2000 to 2500 donor hearts are available.

In developing a short-term pump, two major problems associated with the original design are related to fluid dynamics: the excessive blood damage due to high shear stress and the low pumping efficiency, and blood clotting in the bearing region, which stops the pump after a short period of operation. To make this design usable, it is essential to lower the blood damage to an acceptable level and to increase pumping efficiency so that the power requirement can be minimized. In addition, stagnant regions need to be eliminated in the flow field, especially in the bearing region where blood clotting prevents the impeller from rotating. To complete the design effort, it was essential to quantify the flow characteristics under various combinations of geometry and operating conditions. The JSC/DeBakey design team asked the Ames Research Center (ARC) to implement computational fluid dynamics (CFD) technology to analyze the flow in the device. NASA/ARC has been leading the development of CFD tools for incompressible flows for rocket propulsion and low-speed aerodynamic flow analysis. This technology is most suitable for analyzing the flow in VAD.

Accomplishments to date

An extensive computational analysis resulted in numerous design modifications. A new idea of including an inducer between the flow straightener and the impeller was introduced, an idea that came directly from the work performed in conjunction with the next-generation liquid rocket propulsion system development with NASA's Marshal Space Flight Center. Even though the inducer concept is being used in rocket engines, this is the first time an inducer was introduced in VAD.

In addition to the inducer idea, numerous design improvements were made through the use of CFD results on components such as blade shape, inducer gap, blade lean, and tapered hub step. An 11-day test completed using the newest geometry showed that no clotting occurred in the bearing region between the impeller and diffuser. The final design has passed the two-week requirements.

During FY98, an unsteady solution procedure from inlet cannula to exit was developed. A new computational grid was generated for the improved geometry. Flow through the new design was simulated for three heartbeat cycles.

Significance of the results

The current design is compact and provides patient mobility. The major bottleneck has been the excessive thrombus and blood damage. The current effort resulted in the present design, which eliminates those problems and enables the device to be practically usable. An additional unsteady control mechanism will enhance the patient mobility.

Publications resulting from the study

Kiris, C.; Kwak, D.; and Benkowski, R.: Incompressible Navier–Stokes Calculations for the Development of a Left Ventricular Assist Device. Computers and Fluids, vol. 27, no. 5–6, 1998, pp. 709–719.

Keywords

Biofluid computation, Ventricular assist device

7 Kelvin Pulse Tube Cooler Using Rare Earth Regenerators

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Objectives of the study
To investigate and demonstrate a 7 kelvin pulse tube cooler using rare earths as the regenerator material. These materials possess relatively high heat capacity at low temperatures—an order of magnitude larger than current regenerators that use lead. The increased heat capacity leads to better regenerator effectiveness and subsequently better performing pulse tube coolers. Additionally, the geometric spacing between the flow channels that contain the working gas and regenerative material is crucial for high effectiveness. An inherent problem of spherical packed beds is that the ratio between the thermal diffusion length of the gas and material is essentially fixed. This is the case for the lead spheres. The development of rare earth Neodymium (Nd) ribbon allows independent variation of gas spacing and material spacing, resulting in regenerators with higher effectiveness.

Progress and results
The first-year work examined the optimum flow channel path and regenerator matrix geometry using a linearized two-dimensional pulse tube model developed at Ames. From this, two regenerator designs were selected based on available materials and material processing.

The first design uses spherical Erbium-3-Nickel (Er_3Ni) with diameters ranging from 180 to 250 μm. Because the Er_3Ni comes in spherical shapes, its thermal diffusion length is not optimally matched between the working gas and the spheres. Unfortunately, because of its brittleness, Er_3Ni cannot be extruded into a more preferable geometry, such as wire or ribbon.

The second regenerator design uses Nd ribbons. Neodymium is somewhat ductile and allows a certain amount of bending before fatigue becomes a factor. Annealing also helps to achieve adequate ductility. The material is roll-pressed into a very long ribbon that is 175 μm thick and 3.5 mm wide. It is then wound into coils to form what amounts to “concentric plates.” Several coils are then stacked on top of each other to form stacked coils with an overall cylindrical shape. Gas flows axially from one coil to the next through the channels between the concentric plates. To allow the gas to flow without obstruction between the plates, the plates must be appropriately spaced. Many ridges are thus pressed into the ribbon so as to allow a spacing of 25 μm between plates. Figure 1 shows a photograph of the Nd ribbon with spaced ribs. The current effort now requires testing the material in a pulse tuber cooler.

Additional material processing with the Nd found that it can be drawn into a wire form with sufficient tensile strength for weaving into tight mesh screens. The screens can then be cut and stacked for use in regenerators, thereby allowing a much more homogeneous gas flow. This is expected to lead to higher effectiveness.

Significance of the results
Specific results include:

- Rare earth element Neodymium can be rolled into a ribbon that allows independent variation of working gas spacing and regenerator matrix. This allows optimization between the thermal penetration of the gas and matrix, resulting in lower-temperature regenerators with higher effectiveness.
- Nd can also be drawn into wire form, allowing processing into woven screens, which can be used as the matrix for regenerators.
- As an outcome of the first-year modeling effort, the prediction of increased pulse tube efficiency by reducing steady secondary flows within the pulse tube was validated by Los Alamos National Laboratory (LANL). The prediction of a tapered pulse tube to reduce Reynolds stresses and thus reduce secondary flow was confirmed by experiments at LANL, showing an increase in performance relative to using a straight cylindrical pulse tube.

Generally speaking, this technology will be important for future missions to Mars, where hydrogen liquefaction may be required.

Keywords
Pulse tube, Cryocooler, Regenerator

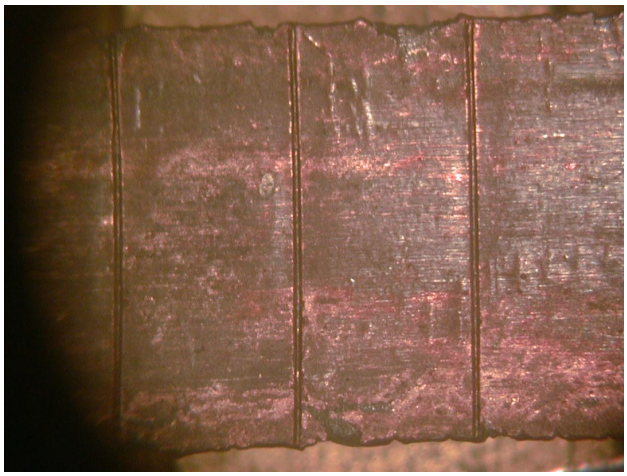

Figure 1. Neodymium ribbon with 25-µm high ribs (vertical). Ribs are 25 µm wide.

Development of a Fully Automatic Mini-Holographic Optical Instrument for Fast Separating and Detecting Amino Acids for Future Planetary Missions

Investigator(s)

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Objectives of the study

To design and construct an instrument that will separate and detect free amino acids of soil samples and/or returned samples from planetary spacecraft missions. Molecular imprinting is one of the major techniques used here to synthesize a stationary phase in affinity chromatographic columns. Molecular imprinted polymers will be developed and evaluated for specific binding properties for underivatized amino acids. Using these molecular imprinted polymers, affinity columns will be prepared and investigated for efficiency of free amino acid separation. Mini-columns are then prepared via established methodology in conjunction with in situ polymerization, developed previously in our laboratory. Finally, with affinity mini-columns in hand, a complete hologram-based capillary electrochromatography (CEC) instrument can be assembled and tested.

Progress and results

Many solvent systems have been tested along with a variety of monomers and cross-linking reagents to search for suitable conditions for polymer preparation via molecular imprinting. Underivatized amino acids have relatively low solubility in common organic solvents and even in aqueous solvent systems. The water-methanol system was considered to be best to achieve an optimum solubility of the template amino acid (i.e., L-Phe), monomer(s), and cross-linker in the solvent system. Reaction conditions were further refined to maximize the number of amino acid-specific binding pockets built within prepared imprinted polymers. Several molecular imprinted polymers were prepared, and their binding properties to the target amino acid were analyzed in a methanol/water system. The amino acid, bound and unbound, was assayed. The assay was based on ninhydrin tests at 570 nm via an ultraviolet (UV)-visible spectrometer. The results indicated that the polymers prepared in the presence of the amino acid indeed retained more of the amino acid than the polymers prepared without the presence of the amino acid. Up to approximately 1 μg of L-Phe was absorbed in 1 mg of polymer. High-performance liquid chromatography (HPLC) columns have also been packed using the synthesized imprinted polymers in order to analyze the separation efficiency of amino acid.

Significance of the results

This study demonstrated that molecular imprinted polymers with favorable affinity for target amino acid can be prepared. More importantly, the developed polymerization conditions are compatible with in situ polymerization, developed earlier in the laboratory. By combining these two methods, an affinity capillary column will be constructed. Mini-columns prepared thereby can then be connected to a well-established holographic detector for instrumentation implementation.

Keywords

Molecular imprinting, In situ polymerization, Capillary electrochromatography, Polymer, Affinity column, Amino acids, Holographic, Hologram

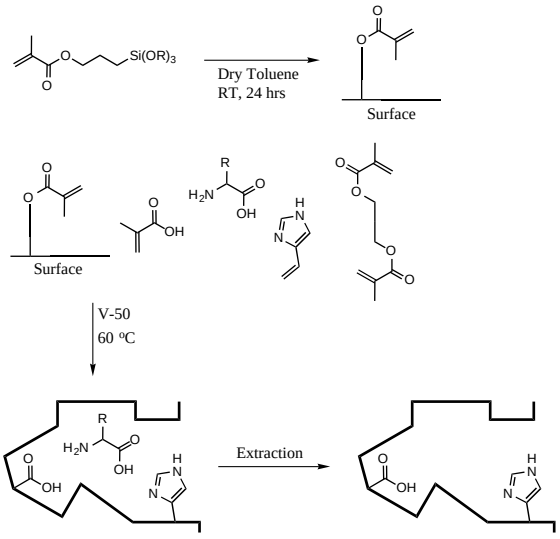

Figure 1. Synthetic Scheme.

Exploring Carbon Nanotubes for Future 1-nm Nanolithography

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Objectives of the study

To develop 1-nm nanolithography for nanoelectronic device fabrication using carbon nanotubes.

Progress and results

Multiwall carbon nanotubes of 10- to 20-nm diameter were prepared by the arc discharge method and purified by the oxidation process. They were made into atomic force microscopy (AFM) tips. The nanotube tips were used to fabricate silicon oxide nanostructures on a silicon surface in tapping mode with the tip biased at –7 to –15 volts against the H-Si surface. They wrote 10-nm-wide nanostructures at speeds up to 0.5 mm/s over a large silicon surface area. Experiment and simulation found that nanotube tips are impervious to high compressive and lateral forces and breakdown in high electric fields. A "cleaving" method was developed to reproducibly obtain dome-closed multiwall nanotube tips with a suitable length for reliable nanolithography.

Significance of the results

Silicon tips based on AFM technologies have been used for nanoscale lithography and data storage. However, they quickly wear down in minutes. This work, for the first time, shows that nanotube tips can be used as nanopencils for writing 10-nm-wide silicon dioxide structures on silicon substrates at a writing rate of 0.5 mm/sec—five times faster than was possible with older AFM tips. More impressively, the nanotube pencils never wear out during nanoscale writing, as other AFM tips often do. The work should "help the development of nanofabrication, since tip wear problems have been an obstacle to the use of probe microscopes in lithography and data storage at the nm size scale." (from Physics News Update, No. 390, Sept. 10, 1998, by Phillip F. Schewe and Ben Stein). We are now working on using 1-nm diameter single wall nanotubes for 1-nm nanolithography.

Publications resulting from the study

Dai, H.; Franklin, N.; and Han, J.: Exploiting the Properties of Carbon Nanotubes for Nanolithography. Applied Physics Letters, vol. 73, no. 11, 1998, pp. 1508–1510.

Garg, A.; Han, J.; and Sinnott, S. B.: Interactions of Carbon-Nanotubule Proximal Probe Tips with Diamond and Graphene. Physical Review Letters, vol. 81, no. 11, 1998, pp. 2260–2263.

Keywords

Lithography, Nanotechnology, Carbon nanotubes

Large-Scale Processing of Carbon Nanotubes

Investigator(s)
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Objectives of the study
To develop a chemical vapor deposition process to grow carbon nanotubes (CNTs) for nanotechnology applications. CNT is a material with extraordinary mechanical and electrical properties. It has the potential for ultralightweight composites, which requires methods to grow large quantities. CNT also has the potential to revolutionize nanoelectronics for which controlled growth on patterned wafers is critical. Two existing techniques, namely laser ablation (from Nobel Laureate Smalley) and carbon arc growth (mainly in Japan), cannot give large quantities for composites; they are not suitable for electronics because CNT is scraped off the walls. The planned chemical vapor deposition (CVD) process, in contrast, is ideal for all applications.

Progress and results
Much of the FY98 effort was on building a CVD reactor. The reactor consists of an approximately two-foot-long quartz chamber enclosed in a high-temperature furnace.

The furnace has three heating zones and is capable of maintaining an isothermal growth zone. The system is capable of taking multiple wafers in a single run; these can be loaded from one end using an arm. The reactor has multiple mass-flow controllers to admit various precursors. The entire system is enclosed under a hood with a glass shower-curtain-like door with all appropriate safety measures.

The precursor system studied first is CO disproportionation. This has been successful and the recipe used has yielded carbon nanotubes, as shown in the scanning electron micrograph (SEM) picture (fig. 1).

Significance of the results
We have demonstrated that a CVD technique using CO disproportionation reaction can grow CNT. Much work remains to be done: understanding of growth mechanisms, and effects of temperature, feed gas composition and flow rate, type of catalyst, and technique to deposit catalyst particles and other system parameters or growth characteristics. When these issues are understood, then growth on patterned substrates can be investigated.

What has been accomplished is a necessary first step on the (long) way to achieving controlled CNT growth on patterned wafers, further device processing, etc. to realize functional devices. This approach also has applications to flat panel displays.

Keywords
Carbon nanotubes, Chemical vapor deposition, Nanotechnology

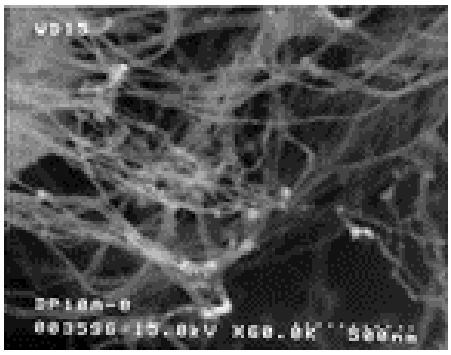

Figure 1. Carbon nanotubes.

Modeling and Optimization of Ultrafast Semiconductor Quantum Well Devices

Investigator(s)
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Other personnel involved
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Objectives of the study
To study the modulation and switching speed limit of the optoelectronic devices based on quantum well structures. Quantum well optoelectronic devices are main ingredients of the current and future information technology. The ultimate speed limit for modulation (data transmission) switching is determined by the microscopic physical processes in such quantum structures. It is, therefore, critical to investigate the influence of the processes such as carrier-carrier scattering and carrier-phonon scattering in a quantum well structure, starting from first-principle microscopic theory. The effects of plasma on modulation speed will be examined. The objectives are 1) to identify each process and 2) to formulate a comprehensive model and develop the relevant computer code for designing and optimizing quantum structures for ultrafast modulation and switching.

Progress and results
The effects of plasma heating on differential optical gain and refractive index change in quantum well structure has been studied. The so-called temperature-induced alpha-factor has been introduced to describe the new effects when temperature becomes a dynamical variable. A simplified model for ultrafast modulations has been developed. Preliminary investigation shows that we can take advantage of plasma heating to achieve modulation and switching. A more extended model is currently being developed.

Significance of the results
The results obtained so far are very promising for achieving ultimate modulation and switching. From a fundamental physics point of view, plasma heating is always a negative for device performance. It shows that we can take advantage of this effect and achieve higher speed than we have expected. The potential increase in modulation speed could be orders of magnitude higher. These results may find other applications as well. Other issues, however, need to be researched before the present results can be implemented to increase communication bandwidth.

Publications resulting from the study

Ning, C. Z.: Partial and Total Alpha Parameters in Semiconductor Optical Devices. Applied Phys. Letters, vol. 72, no. 15, 1998, pp. 1887–1889.

Ning, C. Z.: Temperature Induced Alpha Factor. Proceedings of SPIE, 1998, vol. 3283, pp. 406–410.

Ning, C. Z.; and Hughes, S.: THz Modulation of Semiconductor Lasers through Plasma Heating (to be published).

Keywords
THz modulation, Quantum well lasers, Plasma heating

Toward a Phylogeny of Biological Functions

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Kevin Karplus, University of California, Santa Cruz,
Santa Cruz, CA 95060

David Wolpert, Ames Research Center

Charles Strauss, Los Alamos National Laboratory,
1 Los Alamos Lab., Los Alamos, NM 87545

Objectives of the study
To develop novel computational approaches, based on modern information theory, for incorporating sequence, structural, and functional information about a group of proteins into a single representation, and for using this representation to answer fundamental questions regarding the evolutionary relationships between proteins and their functions. The new methods will be applied to the well-studied superfamily of ligand-gated ion channels as a validation. The evolutionary relationship, if any, between the ligand-gated ion channels and the voltage-gated ion channels will be determined.

Progress and results
In August 1998, a collaboration with Karplus and Wilson led to the creation of a set of sequence alignments for the entire superfamily of ligand-gated ion channels using standard methods (hidden Markov models). This alignment represents the most comprehensive comparison of these sequences to date, and is a necessary step in determining the relationships between similar proteins of a given family. The construction of this database is necessary for further studies.

In collaboration with the University of California, San Francisco, the above-described alignment along with experimentally derived constraints were used to construct, de novo, the three-dimensional structure of the human glycine receptor, one member of the superfamily of ligand-gated ion channels. No high-resolution structural data for members of this superfamily are currently available. The computed structure is being used to explore how homology data can be used to infer structure and functions of evolutionarily related proteins.

In collaboration with the Los Alamos National Laboratory, the application of self-dissimilarity, a new concept in the theory of complex systems, was explored as a means for incorporating structural information into protein sequence comparisons. This promising technology is still being developed for application to the problem at hand.

Significance of the results
The sequence alignment spanning the superfamily of ligand-gated ion channels is the most comprehensive comparison of these sequences to date and provides an excellent testbed for new methods of sequence comparison. Combining sequence alignment with experimentally derived constraints on structure holds promise for developing new, comprehensive approaches to understanding functions of evolutionary related proteins for which high-resolution structural data are not available.

Keywords
Information theory, Homology modeling, Monte Carlo, Evolution, Ion channels

DNA Damage Repair in Nature?

Investigator(s)
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Other personnel involved
Nathaniel Pearson, SETI Institute, ARC

Jon Ashen, National Research Council (NRC),
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Genie Moore, SETI Institute

Stephanie Gliege, Astrobiology Academy student

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Objectives of the study
DNA, the repository of genetic information, is subject to damage. The consequences of DNA damage range from small changes in base sequence to cancer and death. Alternatively, such damage may be repaired by the cell. Several mechanisms of DNA damage repair have been characterized in the laboratory. Surprisingly, little is known about the mechanisms, timing, or extent of DNA damage repair in nature. Without this knowledge we cannot know the role of DNA damage in exobiology, astrobiology, ecology, or, for that matter, medicine. While studying microbial ecosystems in the field, we made a serendipitous discovery that may constitute the first measurement in nature of a kind of DNA damage repair called excision repair. The objective of this study is to determine if we are indeed measuring DNA damage repair in nature and, secondarily, to develop a standard technique to measure excision repair in the field. The ultimate goal of this work is to have a reliable method to measure excision repair in nature in order to apply it to questions of the role of UV in astrobiology, exobiology, ecology, and physiology.

Progress and results
1. Equipment has been purchased to measure ultraviolet (UV) radiation in the field, and to improve efficiency of DNA analyses in the lab.
2. Two sets of measurements have been made of phosphate uptake in Yellowstone National Park on *Cyanidium caldarium*. These measurements confirmed that increases in apparent DNA synthesis as measured by incorporation of ^{33}P-phosphate into DNA cannot be attributed strictly to increases in uptake of radioactive phosphate.
3. Growth rate of yeast has been measured outside under three radiation regimes. As in the case of photosynthetic organisms, UV has a measurable negative effect on growth rate in yeast.
4. In September, we collected *Cyanidium caldarium* every 1.5 hours for 24 hours. The samples have been analyzed for total DNA per cell using flow cytometry, and possession of thymine dimers, a common form of DNA damage. The flow cytometry results show two distinct populations of cells with chlorophyl in the pond, which we have tentatively identified as *Cyanidium caldarium* and *Chlorella sp*. The dimer analysis results suggest that there are a negligible number a thymine dimers through the day. They are either repaired extremely quickly or the damage to the DNA is in some other form.

Publications resulting from the study

Rothschild, L. J.; and Pearson, N.: Application of Single Cell Gel Electrophoresis (Comet Assay) to Detection of DNA Damage in Protists. J. Phycol., vol. 34 (suppl.), no. 51, 1998.

Keywords
UV radiation, Excision repair, Algae

New Insights into the Origin of Life: Dynamical Behavior of Networks and Cellular Automata

Investigator(s)

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Other personnel involved

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Z. Peng, University of Connecticut Health Center, Farmington, CT 06030

Gary Haith, Stanford University

Dimitris Stassinopoulos

Objectives of the study

To understand the fundamental dynamical processes relevant to the origin of life and its subsequent evolution; to shed light on the formation of increasingly complex organic structures, and the subsequent development of living organisms. Also examined in detail is Stuart Kauffman's proposal that spontaneous generation of complexity—self-organization—may have operated in parallel with Darwinian evolution.

It is assumed that the evolution of prebiotic forms can be modeled with dynamical network systems, including Kaufmann nets and cellular automata. Therefore, a subsidiary objective is to use genetic and other modern programming methods, as well as innovative time series analysis techniques, to characterize the dynamical evolution of these networks and assess their relevance to the origin of life.

Most previous work has concentrated on the periodic cycles that any finite net ultimately reaches; here for the first time the early transient behavior, which ranges from regular to stochastic, is examined.

Progress and results

Specific results include the development of software to (1) model temporal structure; (2) characterize dynamical behavior; and (3) deduce network structure using synthetic time series generated by simulations of the biological system. Specific algorithms for all these have been developed and published (see publication list). A combination of older work (Scargle 1990) plus a novel Bayesian approach (Scargle 1998) was developed for (1), and (2) followed from relatively straightforward analysis involving power spectra and scalegrams—the wavelet analogs of power spectra. Result (3) is referred to as "reverse engineering," because it represents deducing the nature of the inner workings of a process from the evolutionary behavior of its output signals. An example of the data analyzed is a time series representing the rate of self-regulation of the gene system, but many other dynamical simulations have been carried out.

A generalized network construct, called Molecular Networks, or MolNets, extends both Kauffman nets and Cellular Automata to form networks that more clearly have the potential for representing spontaneous self-organization for molecules.

During the past year a study was conducted in collaboration with Stanford University on an unconventional theory of gene regulation. The argument that an exquisite molecular machine such as a living cell must be under the control of commands stored in the genome was studied.

An analogy was made between the genome of an organism and a computer hard disk, in which a gene that codes for a protein corresponds to a data file on the computer disk. In this theory there must be DNA control sequences in the genome, corresponding to the operation codes in the computer.

Literature search reveals that long repeats in a whole genome have not been systematically studied. A sophisticated computer program has been developed that catalogs all repeated elements. A constant depth tree, with four nucleotides A, C, G, T, as four branches is built. Such a tree automatically sorts all the constant-length subsequences in a genome. The combined use of pointer/union makes the algorithm so memory efficient that DNA repeats of arbitrary length can be handled. In tests on the 4-million base-pair E. coli genome, a 574 base-pair long sequence that repeats 8 times was found; there is also a large number of shorter repeats, much more than allowed by chance. These repeats are currently being interpreted. A computer visualization code to facilitate this work is also being developed.

This repeat identification algorithm has been applied to two gene regulation problems of great biological interest. In collaboration with the University of Connecticut Medical Center, search for natural antisense controls in the 100-million base-pair genome of

C. Elegans will be made. The release of the completely sequenced genome is scheduled for December 1998. It has been discovered experimentally that short RNA sequences of 15 to 50 nucleotides in length can suppress the expression of a gene. The short sequence must be complementary to the gene. In the second problem, promoters through the proximity of more than two frequent repeats, identified as protein binding, are identified. Such transcription-factor proteins often are grouped together near a promoter.

Much of this work has just reached the stage where its exciting potential is evident, but the details remain to be worked through.

References

1. Liang, S.; Fuhrman, S.; and Somogyi, R.: REVEAL, A General Reverse Engineering Algorithm for Inference of Genetic Network Architectures. Proceedings of the 1998 Pacific Symposium on Biocomputing, vol. 3, 1998, pp. 18–29.
2. Szallasi, Z.; and Liang, S.: Modeling the Normal and Neoplastic Cell Cycle with "Realistic Boolean Genetic Networks": Their Application for Understanding Carcinogenesis and Assessing Therapeutic Strategies. Proceedings of the 1998 Pacific Symposium on Biocomputing, vol. 3, 1998, pp. 66–76.
3. Scargle, J. D.: Studies in Astronomical Time Series Analysis. IV: Modeling Chaotic and Random Processes with Linear Filters. Astrophys. J., vol. 359, no. 2, 1990, pp. 469–482.
4. Scargle, J. D.: Studies in Astronomical Time Series Analysis. V. Bayesian Blocks, A New Method to Analyze Structure in Photon Counting Data. Astrophys. J., vol. 504, no. 1, 1998, pp. 405–418.
5. Scargle, Jeffrey D.: Genetic Network Modeling in Light of Large Scale Data Acquisition. Paper presented at the 78th Statistical Mechanics Conference, Rutgers University, Dec. 15, 1997.
6. Scargle, Jeffrey D.: Random Boolean Network. Paper presented at the 1998 Bioinformatics Seminar, Stanford Medical School, Feb. 26, 1998.

Keywords

Genomics, Bioingormatics, Gene regulation, Gene expression, Time series analysis

Dexterous Walking for Mobility in Unstructured Terrain

Investigator(s)
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John Bares and Dimitrious Apostolopolous,
Carnegie Mellon University, Pittsburgh, PA

Objectives of the study
To develop gait planning and control for high degree-of-freedom, walking robots with application to locomotion in unstructured, rough terrain. This effort will develop new control techniques for dexterous walking and mobility, with an emphasis on behavior- and neural-based methods. In addition, these control techniques will allow the integration with reactive and deliberative control methodologies. To support development of these new algorithms, both a virtual environment simulator as well as a walking mechanism hardware testbed will be developed to demonstrate rough-terrain locomotion.

Progress and results
The second year of this research focused on building both the hardware and software infrastructure for legged mobility. The basic electrical and mechanical design for the walking robot testbed was developed, and detailed mechanical design for the legs was begun. A virtual environment simulator, which allows the development of gait planning algorithms in realistic terrains, was developed.

The basic walking chassis under development is a radially symmetric hexapod with orthogonal legs (see fig. 1). This leg/body configuration allows the unconstrained body translation regardless of yaw. Each leg comprises three degrees of freedom: a rotary hip, a prismatic knee, and a prismatic foot. The hip and knee joints operate in the horizontal plane, while the foot operates in the vertical plane. This leg configuration decouples horizontal and vertical body motion. This minimizes the overall energy consumed by locomotion, since support can be achieved via mechanical braking of the vertical actuator. The necessary motors and control amplifiers for all six legs have been purchased.

The control system of the walking robot testbed allows for hybrid torque-position control over all 18 degrees of freedom in the walking robot. Joint feedback is generated by joint position sensors (potentiometers), semiconductor strain gauges, and contact switches in the foot. In addition, attitude feedback is generated by a compass-inclinometer. The control system consists of a 68060 processor with 20 12-bit analog output channels, 56 12-bit analog input channels, and 40 digital channels. Analog inputs are used to measure strain gauge and potentiometer signals, and analog outputs are used to drive pulse-width modulated (PWM) amplifiers, which in turn drive the motors.

The control system of the walker has been integrated with a graphical, virtual environment simulator. This simulator simulates the inputs from feedback sensors and the joint responses and allows high-level planning algorithms to be tested. A reactive gait generation algorithm, which automatically adjusts body pose and gait in response to terrain disturbances, has been integrated.

Significance of the results
The ability to locomote efficiently and autonomously on harsh planetary surfaces is a key requirement for the exploration of the solar system. The results to date will allow development and evaluation of advanced gait-control algorithms, making walking a viable locomotion technique for NASA missions. In addition, the mechanical configuration being developed is optimized around power consumption and maneuverability, key factors in the design of surface exploration systems.

Keywords
Legged locomotion, Walking, Planning, Robot navigation, Planetary rovers

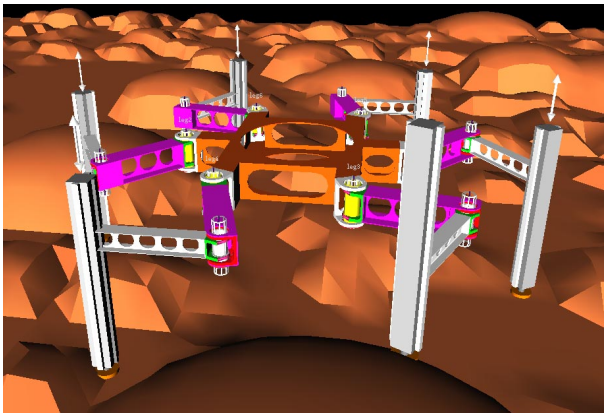

Figure 1. Omnidirectional hexapod.

A Deployable Vortex Diffuser for Reducing Blade/Vortex Interaction Noise

Investigator(s)
Chee Tung and Ken McAlister, Ames Research Center, Moffett Field, CA 94035-1000

Objectives of the study
To develop and test a new device on rotor blades that will reduce the blade/vortex interaction (BVI) noise during helicopter descent without compromising the desirable characteristics of the rotor at other flight conditions.

Progress and results
Prior work reported in the literature has encouraged the consideration of two methods for rapidly dissipating the vortex trailing from the tip of a rotor blade. One method relies on secondary-vortex pairing and the other on severe turbulent diffusion. A rotor blade model is being prepared that incorporates a device on the upper surface near the tip of the blade. The device can be placed in a variety of orientations relative to the free-stream flow, including those that satisfy the two proposed dissipation methods. The seven-foot-diameter model rotor will be tested in hover to demonstrate the effectiveness of the device.

Two in-flight deployment concepts have been designed based on shape-memory alloy (SMA) technology. These two concepts (see figures) individually satisfy the two vortex-dissipation geometries described previously. The first concept employs a small wing oriented normal to the rotor blade surface (figure 1). When vortex pairing is not required, the SMA spring-driven actuator is relaxed (fail-safe condition), thereby allowing the aerodynamic pitching moment to maintain the wing at a minimum-drag angle. When the rotor is descending and vortex pairing is desired, a small current through one spring easily moves the wing to an angle that produces the needed secondary vortex. If desired, this angle can be "locked in" using a SMA brake that drives a plunger into indentations around the periphery of the large sprocket.

The second concept employs a spoiler-like surface that can be raised normal to the rotor blade surface to create substantial turbulence in the core of the trailing vortex (figure 2). When the rotor is descending and turbulent dissipation is desired, a small current through one of the wires rapidly deploys the spoiler. In addition to moving the spoiler in a particular direction, the action of one "active" wire places additional strain on the other "relaxed" wire. This opposing wire scenario ensures that the spoiler can be retracted without depending on aerodynamic forces.

Significance of the results
These two concepts demonstrate the potential applicability of shape-memory alloy technology for deploying flow-altering devices on rotor blades. The upcoming model rotor test will show the efficacy of two different methods for rapidly dissipating the trailing vortex.

Keywords
Trailing vortex, Vortex spoiler, Blade/vortex interaction, Shape-memory alloy

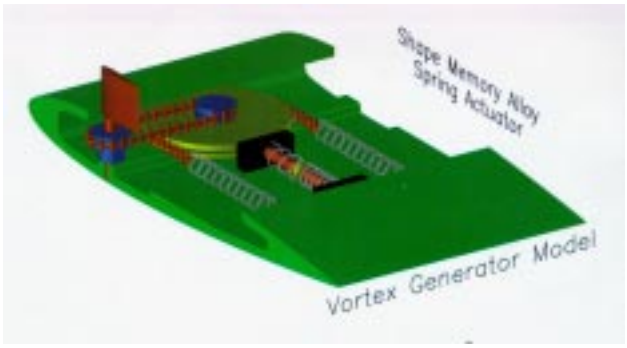

Figure 1. Vortex generator model.

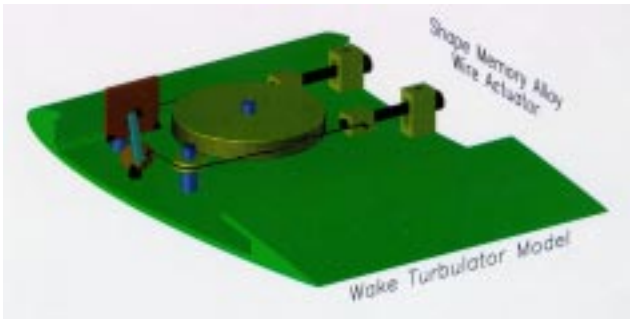

Figure 2. Wake turbulator model.

Adaptation to Virtual Gravitational Environments

Investigator(s)
Robert B. Welch, Michael Aratow, Wanda Boda,
Gene Korienek, and Robert Whalen,
Ames Research Center, Moffett Field, CA 94035-1000

Objectives of the study
The objectives are threefold:

- To create, test, modify, and ultimately perfect a treadmill-lower body positive pressure (LBPP)-virtual environment device designed to simulate the visual (optical flow pattern) and kinesthetic/proprioceptive experience of walking in simulated altered gravity (e.g., 0.17 g, 0.38 g, 1.50 g).
- To measure the initial effects of these environments on balance and posture.
- To induce and measure adaptation to this environment, as measured in terms of various characteristics of walking gait and walking accuracy.

Progress and results
The design, construction, and testing of the altered gravity simulator has taken much longer than expected, because numerous unforeseen technological difficulties have been encountered. The major problem has been the design of a treadmill that is relatively "transparent" to the user. A couple of engineering graduate students at Stanford have assisted in creating and building a device that alters the speed of the motorized treadmill as a function of the subject's walking speed. However, this control system is not yet functioning optimally and needs further work. The LBPP and computer-controlled virtual environment, on the other hand, are both in place and ready to go.

A proposal has been submitted to the NASA research announcement (NRA) in order to continue this research.

Significance of the results
The data from the human subjects will allow characterization of the immediate effects of various levels of simulated altered gravity on posture and balance, as well as the ability of these subjects to adapt their walking behavior to these unusual gravitational environments as the result of continued, active exposure to them. In addition to the acquisition of this important scientific information, the presumed demonstration of human adaptability to the altered gravity simulator will pave the way to designing a "preflight adaptation trainer" that might be carried aboard a spacecraft bound for Mars (or other extraterrestrial bodies) and used by astronauts to prepare for their arrival at these new gravitational environments.

Keywords
Altered gravity, Lower body positive pressure, Adaptation

Assessment of Noise Exposure and Possible Resulting Hearing Loss in Commercial Aircraft Cockpits

Investigator(s)

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Durand R. Begault, San Jose State University Foundation, San Jose, CA 95192-0041

Objectives of the study

To optimize auditory display design technology by characterizing the commercial aircraft acoustic environment and the hearing capacity of pilots through quantifiable measurements. This involves data collection of acoustic spectral data from commercial aircraft flight decks and audiogram data from pilots, and data analysis for a possible correlation between hearing loss and noise exposure.

Progress and results

Audiogram data from 64 pilots were analyzed. Within specific age groups, the proportions responding positively for hearing loss and tinnitus exceed the corresponding proportions in the general population reported by the National Center for Health Statistics.

Acoustic measurements to date have been performed from the flight deck jumpseat position on aircraft operated by a major U.S. cargo carrier. Acoustic levels (one-third octave band spectral data) were measured for two different flight decks (Airbus 310 and the relatively older Boeing 727). Preliminary results indicate an overall level difference of 9 decibels (A-weighted L_{eq}), the 727 being the loudest at about 84 dB during the cruise phase of flight. Additional data collection (spectral data and noise dose data) is planned during FY99, and audiogram data is to be collected from 24 additional commercial pilots.

Significance of the results

The results contribute substantially to forming engineering guidelines for adapting advanced acoustic avionics displays using three-dimensional (3-D) sound technology to personalized hearing sensitivity curves. The data also supports accurate acoustic simulations in flight simulator experiments. Finally, the levels measured in the Boeing 727 were high enough to suggest implementation of measures to improve intracockpit communications and mitigate auditory fatigue.

Publications resulting from the study

Begault, D. R.; Wenzel, E. M.; Tran, L. L.; and Anderson, M. R.: Survey of Commercial Airline Pilot's Hearing Loss. Perceptual and Motor Skills, vol. 86, no. 1, 1998, p. 258.

Begault, D. R.: Virtual Acoustics, Aeronautics and Communications. J. Audio Engineering Soc., vol. 46, no. 6, 1998, pp. 520–530.

Keywords

Hearing loss; Acoustic measurements; Virtual acoustic displays

Constraining the Silicate Mineralogy in Comet Hale–Bopp: Discovery of Abundant Pristine Mg-Rich Pyroxene Crystals

Investigator(s)
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Charles E. Woodward and David E. Harker, University of Wyoming, Laramie, WY

Other personnel involved
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Chiyoe Koike, Kyoto Pharm. Univ., Kyoto, Japan

Objectives of the study
To determine the causes for the changes in shape of the 10-μm silicate features observed in comet Hale–Bopp with the Ames High-Efficiency Infrared Faint-Object Grating spectrograph (HIFOGS) spectrometer over a large range of heliocentric distances. To constrain the silicate mineralogy of the dust in the inner coma. To investigate the sources for the silicate dust grains in the comet by comparing with solar nebula materials, interplanetary dust particles, and star dust.

Progress and results
Modeling of the observed dust emission from comet Hale–Bopp led to the discovery of Mg-rich pyroxene crystals in the coma. These crystals are apparent only in the 10-μm spectrum when the comet is close to perihelion because the Mg-rich pyroxene crystals in Hale–Bopp are cooler than the other silicate minerals. As a consequence of their high Mg content, the pyroxene crystals do not absorb as efficiently as other minerals. The pyroxene crystals are also about ten times more abundant than the other silicate mineral species. This is in agreement with the preponderance of pyroxene interplanetary dust particles (IDPs) and the recent reanalysis of the PUMA-1 flyby of comet Halley. Yet, before Hale–Bopp, only olivine crystals were detected spectroscopically in comets, probably because the pyroxene crystals are significantly cooler than the other mineral species. Radiative equilibrium computations show that pyroxene crystals are expected to be 150K cooler than olivine crystals with the same high Mg content of Mg/(Mg + Fe) = 0.9.

Significance of the results
If the pyroxene crystals in Hale–Bopp are solar nebula condensates, then 1) they probably had to form during early FU Ori phases when the inner disk was hot enough and 2) then be transported out to the region of formation of icy planetesimals *without* being reheated. Reheating events usually reincorporate iron back into the crystals or form iron-rich rims. Thus, Hale–Bopp's Mg-rich crystals are pristine condensates. Hale–Bopp's resonances are well matched by spectra of pyroxene IDPs. One-third of IDPs have been shown to have significant deuterium enrichments, thus indicating that they contain presolar material. By spectroscopic analogy to IDPs, the Mg-rich pyroxene crystals in comet Hale–Bopp may be presolar grains. If so, then the comet contains largely interstellar medium (ISM) silicates. ISM grains must have passed through the cold prenatal cloud, where complex organic chemistry can occur on grain mantles, forming such complex molecules as amino acids. Thus, perihelion passages of comets may deliver both presolar pyroxene crystals and prebiotic materials.

Implications for Origins of Protoplanets
The Infrared Space Observatory Short-Wavelength Spectrometer (ISO SWS) recently discovered Mg-rich crystals in the dust-forming winds of older Asymptotic Giant Branch (AGB) stars, giving a possible interstellar source for comet crystals. The fact that the pyroxene crystals are cooler than the other silicate grain components also impacts the interpretation of the discovery of Mg-rich silicate crystals in some premain sequence Herbig Ae stars and in main sequence β Pic-like stars with debris disks. The ISO SWS observers suggest that the crystals are forming in the regions that they are seen. We suggest that Mg-rich crystals condense in the early phases of disk evolution, at a time when they are not detectable in contrast to the hotter iron-rich amorphous (glassy) particles that are subjects of melting and reheating events. Later when inner disks are partially dissipated or cleared of iron-rich particles by their agglomeration into protoplanetesimals, then the Mg-rich crystals can be detected. Thus,

we speculate that the discovery of Mg-rich crystals only in the more evolved young stellar systems is correlated to the maturity of their protoplanetary formation processes.

Keywords
Comets, Pyroxene crystals, Presolar grains

Appendix A-1
Final Reports

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Solid-State Oxygen Microsensor for Atmospheric-Entry Applications

Investigator(s) (show affiliation)

John A. Balboni, Doug Fletcher, and Howard Goldstein, ARC; K. R. Sridhar, University of Arizona

Funding

Year Initiated FY97

Total prior to FY 98 $20,000

Total expended in FY 98 (Estimated)

In-house $160,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 98 $160,000

Requested for FY (If any)

Status of Study

☒ Completed in FY 98 ☐ Continued in FY

If continued in FY ☐ With funds remaining? ☐ With FY funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To establish the feasibility of using a unique ceramic microsensor on the surface of spacecraft heat shields to measure oxygen pressure in flight. This investigation successfully demonstrated the integration and survival of the sensor during simulated atmospheric flight in the Ames arc-jet plasma wind tunnels.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

None

Planned future work

Continue sensor development using laboratory arc-jet equipment set up for this purpose at the University of Arizona. Continue characterizing arc-jet flow stream constituents and thermodynamic state using laser-induced fluorescence techniques. Propose flight experiments to demonstrate the viability of the sensor.

Prepared by	Org. Code	M/S	Phone
John Balboni	ASF	229-4	(650) 604-6064

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Visual Servocontrol Applied to Mobile Robot Navigation

Investigator(s) (show affiliation)

Maria Bualat, Gary Haith, Hans Keaton-Thomas, and David Wettergreen, ARC; Matt Deans, CMU

Funding

Year Initiated FY97

Total prior to FY 98 $40,000

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 98 $40,000

Requested for FY 99 (If any) 0

Status of Study

☒ Completed in FY 98 ☐ Continued in FY

If continued in FY ☐ With funds remaining? ☐ With FY funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?) TRIWG funded Accurate Positioning in Natural Terrains

to Other (identify)

Purpose of investigation

To develop a visual approach to short-range and terminal mobile robot navigation. Visual servocontrol techniques for mobile robots will be developed; these techniques will be implemented on board under realistic computing and telemetry constraints; and performance will be qualified and compared to traditional methods. This approach will be demonstrated in realistic field experiments.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The visual servosoftware has been ported to the Carnege Mellon University Nomad rover architecture, and will be used early in 1999 in Antarctica to search for meteorites.

Planned future work

Extensive testing of the system is planned during the Marsokhod field test in the Mojave desert, currently scheduled for February 1999. Further research will be conducted under the Accurate Positioning in Natural Terrains topic funded by TRIWG.

Prepared by	Org. Code	M/S	Phone
Maria Bualat	IC	269-3	(650) 604-4250

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Life under a Simulated Martian Atmosphere: Past, Present, and Future

Investigator(s) (show affiliation)

David C. Catling, Christopher P. McKay, Charles S. Cockell, and Robert M. Haberle, ARC; Hilary F. Waties, Stanford U.

Funding

Year Initiated FY98

Total prior to FY ____ ____

Total expended in FY 98 (Estimated)

In-house $50,000

Contracts (identify) ____

Grants (identify) ____

Expected completion date 9/30/98

Authorized in FY 98 $50,000

Requested for FY ____ ____
(If any)

Status of Study

☒ Completed in FY 98 ☐ Continued in FY ____

If continued in FY ____ ☐ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?) ____

to Program (name?) ____

to Other (identify) ____

Purpose of investigation

To develop methodologies to determine the threshold of pressure and CO_2 at which various organisms can live to assess survival under Mars-like conditions, including development of an atmospheric simulation chamber with gas control and sensitive (<1 ppm) gas chromatograph analysis capability to determine the gas exchange metabolism of various organisms. These organisms range from microbial life relevant to post and current Mars to higher-order organisms relevant to future closed-loop life-support ecosystems.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Cockell, C. S.; Catling, D. C.; and Waites, H. F.: Insects at Low Pressure: Applications to Artificial Ecosystems and Implications for Global Terrestrial Distribution. Life Support and Biosphere Science (in review), 1998.

Planned future work

The atmospheric simulation analysis system that has been developed is being used for a variety of ongoing biological measurements, including further assessment of microbial metabolism under high CO_2 conditions, in particular, the effects on the net photosynthetic rate of cyanobacteria in different atmospheres representative of early Mars and Precambrian Earth. These effects have implications for the coevolution of atmospheres and life.

Prepared by	Org. Code	M/S	Phone
David Catling	SST	245-3	(650) 604-1504

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Active Control of Instability Waves in a Laminar Boundary Layer

Investigator(s) (show affiliation)

Sanford Davis, ARC; Anthony Dietz, MCAT Inst., ARC

Funding

Year Initiated FY97

Total prior to FY 98 $40,000

Total expended in FY 98 (Estimated)

In-house $5000

Contracts (identify) $35,000 (MCAT Inst.)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 98 $40,000

Requested for FY (If any)

Status of Study

☒ Completed in FY 98 ☐ Continued in FY

If continued in FY ☐ With funds remaining? ☐ With FY funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To develop and test an active wave cancellation scheme for boundary layer transition control. The proposed control unit will consist of an array of microphones and speakers mounted in a cavity beneath the surface of a flat plate. The use of spanwise-distributed actuators introduces the potential to cancel both two- and three-dimensional instability waves. Development and testing of the control scheme will be carried out in a low-speed wind tunnel with the boundary layer excited by artificially generated two- and three-dimensional disturbances. These known and repeatable disturbances will provide a known input to the control system, allowing a detailed study of the cancellation process and optimization of the control algorithms.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Dietz, A. J.: Active Control of Instabilities in a Laminar Boundary Layer. AIAA Paper 99-0922, presented at the 37th Aerospace Sciences Meeting, Reno, Nev., Jan. 11–14, 1999.

Planned future work

Further optimization of the three-dimensional cancellation scheme will continue until the end of the calendar year. This study centered on measuring the physics of the cancellation process and demonstrating the feasibility of the cancellation scheme for three-dimensional instabilities. Future work would seek to improve the control algorithms with a view to canceling random instability waves.

Prepared by	Org. Code	M/S	Phone
Sanford Davis/Anthony Dietz	AIP	260-1	(650) 604-4137

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Early History of the Biogeochemical Carbon Cycle Can Be Illuminated by Isotopic Microanalyses of Rocks Using a UV Laser

Investigator(s) (show affiliation)

David J. Des Marais, ARC

Funding

Year Initiated FY98

Total prior to FY 98 0

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 98 $40,000

Requested for FY ____ (If any)

Status of Study

☒ Completed in FY 98 ☐ Continued in FY ____

If continued in FY ____ ☐ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To demonstrate the suitability of an ultraviolet laser to extract carbon from geological samples and fresh organic matter for stable isotopic analysis. To combine a laser, microscope, sample positioning stage, and sample chamber swept by a gas stream to gather sample gas. To demonstrate that analyses can be obtained at levels of accuracy and precision required for geochemical interpretation of the origin of the phases under study. Commercially available components must be integrated with a new sample chamber, and an isotope mass spectrometer system most suitable for the isotopic analysis must be selected.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

Prepared by	Org. Code	M/S	Phone
David Des Marais	SSX	239-4	(650) 604-3220

ARC 735 (Sep 97)E Previous editions are obsolete

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Miniaturized Haptic Interface for Precision Haptic-Visual Interaction

Investigator(s) (show affiliation)

Stephen R. Ellis, ARC; Bernard D. Adelstein, UC Berkeley, ARC; H. Kazerooni and D. Gayme, UC Berkeley

Funding

Year Initiated FY97

Total prior to FY 98 $20,000

Total expended in FY 98 (Estimated)

In-house $60,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 98 $60,000

Requested for FY (If any)

Status of Study

☒ Completed in FY 98 ☐ Continued in FY

If continued in FY ☐ With funds remaining? ☐ With FY funds?

If transitioned to other funding, to RTOP (number?) 519.xx.xx (full number pending)

to Program (name?)

to Other (identify)

Purpose of investigation

To design, build, and evaluate a small-scale force-feedback haptic interface for precision manual interaction with virtual and teleoperated environments. An intended outcome is contribution to a set of standards or guidelines for the development of future equipment for high-fidelity "palpable" rendering of mechanical features.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Adelstein, B. D.; Gayme, D. F.; Kazerooni, H.; and Ho, P.: Three Degree of Freedom Haptic Interface for Precision Manipulation. To appear in Proceedings, Dynamic Systems and Control, Am. Soc. Mechanical Engineers, New York, 1998.
Adelstein, Bernard D.: Three Degree of Freedom Parallel Mechanical Linkage. U.S. Patent No. 5816105, Oct. 6, 1998.

Planned future work

The miniature haptic interface, which is now being assembled, will be integrated with spatially and temporally conformal visual environments. A series of human performance studies to ascertain correlations between human performance metrics and engineering characterizations of haptic interface quality (i.e., linkage, actuator, and mechatronic control properties) is planned. The application domain for such performance data and resulting models would include advanced precision manual tools such as those needed for remote and virtual surgical procedures.

Prepared by	Org. Code	M/S	Phone
Bernard D. Adelstein	IHH	262-2	(650) 604-3922

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Laminar Flow Fairings for Acoustic Sensors and Arrays

Investigator(s) (show affiliation)

Clifton Horne, Kevin James, and Chris Allen, ARC

Funding

Year Initiated FY97

Total prior to FY ____ ____

Total expended in FY 98 (Estimated)

In-house $50,000

Contracts (identify) ____

Grants (identify) ____

Expected completion date 9/30/98

Authorized in FY 98 $50,000

Requested for FY 99 0
(If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☐ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?) 519-20-22

to Program (name?) ____

to Other (identify) ____

Purpose of investigation

To generate baseline reference data and guidelines for designing fairings for both small and large arrays for future aeroacoustic research. This study was a preliminary investigation of the feasibility and effectiveness of using natural laminar flow (NLF) and suction hybrid laminar flow (HLF) fairings to reduce sensor self-noise.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

The NLF fairing has been adapted for evaluation in the 40- by 80-Foot Subsonic Wind Tunnel in the near future. Free-stream turbulence near the fairing and background noise will be measured for comparison with conventional probes and with the results from the 14-Inch Indraft Wind Tunnel in the Fluid Mechanics Laboratory.

Prepared by	Org. Code	M/S	Phone
Clifton Horne	AIP	247-2	(650) 604-4571

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Microwave Remote Sensing of Thermal Protection Materials for Vehicle Health Monitoring

Investigator(s) (show affiliation)

E. Irby, Joan Salute, and Huy Tran, ARC; Craig Dobson, University of Michigan

Funding

Year Initiated FY97

Total prior to FY 98 $20,000

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify) $20,000 (U. Michigan)

Expected completion date 9/30/98

Authorized in FY 98 $60,000

Requested for FY ____ (If any)

Status of Study

☒ Completed in FY 98 ☐ Continued in FY ____

If continued in FY ____ ☐ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To investigate microwave techniques for remote monitoring of the status of thermal protection materials used on spacecraft such as the Space Shuttle.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Results will be used to make recommendations to industry for vehicle health monitoring on reusable launch vehicles (RLVs).

Planned future work

Investigate the use of microwave emission techniques on a variety of damaged thermal protection systems (TPSs).

Prepared by	Org. Code	M/S	Phone
Jody Joseph	ASM	234-1	(650) 604-2054

ARC 735 (Sep 97)E Previous editions are obsolete

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Design and Study of Carbon Nanotube Electronic Devices

Investigator(s) (show affiliation)

Richard L. Jaffe, ARC; Jie Han, MRJ, Inc., ARC

Funding

Year Initiated 1997

Total prior to FY 98 $20,000

Total expended in FY 98 (Estimated)

In-house $34,000

Contracts (identify) $20,000 (Eloret Inst.)

Grants (identify) $6000 (U. North Carolina NCC2-5291)

Expected completion date 9/30/98

Authorized in FY 98 $60,000

Requested for FY 99 (If any) 0

Status of Study

☒ Completed in FY 98 ☐ Continued in FY ____

If continued in FY ____ ☐ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?) ____

to Program (name?) IPT for Electronic Devices and Nanotechnology

to Other (identify) ____

Purpose of investigation

Carbon nanotubes (CNTs), hollow cylinders formed by rolling over a graphene sheet, can be metallic or semiconducting, depending on the tube helicity and diameter. Because of their small feature size, ~1-nm diameter, CNTs can be used as quantum wires for single electron transistors or heterojunctions for diodes and transistors. The objective of this work is to explore, using quantum mechanics calculations and molecular simulations, the possibilities for making CNT nanoelectronic devices.

FY 97 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Han, J.; Anantram, M. P.; Jaffe, R. L.; Kong, J.; and Dai, H.: Observation and Modeling of Single Wall Carbon Nanotube Bend Junctions. Phys. Rev. B, vol. 57, 1998, pp. 14983–14989.

Han, J.: Energetics and Structures of Fullerene Crop Circles. Chem. Phys. Lett., vol. 282, no. 2, 1998, pp. 187–191.

Han, J. and Jaffe, R.: Energetics and Geometries of Carbon Nanoconic Tips. J. Chem. Phys., vol. 108, no. 7, 1998, pp. 2817–2823.

Planned future work

This research was transitioned into a mainstream activity of the IPT for Electronic Devices and Nanotechnology.

Prepared by	Org. Code	M/S	Phone
Richard L. Jaffe	ASC	230-3	(650) 604-6458

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Calculation of the Free Energy, Thermal Energy, and Entropy of Self-Assembling Nanostructures in Solutions

Investigator(s) (show affiliation)

Richard L. Jaffe, ARC; Timur Halicioglu, Eloret Inst., ARC

Funding

Year Initiated FY97

Total prior to FY 98 $40,000

Total expended in FY 98 (Estimated)

In-house

Contracts (identify) $40,000 (Eloret)

Grants (identify)

Expected completion date 9/1/98

Authorized in FY 98 $40,000

Requested for FY 99 0 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☐ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?) IPT for Electronic Devices and Nanotechnology

to Other (identify)

Purpose of investigation

To understand how configurational stability of nanoscale particles and assemblies is influenced by the surrounding medium (e.g., solvent).

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

This work has been integrated into the IPT for Electronic Devices and Nanotechnology.

Prepared by	Org. Code	M/S	Phone
Richard L. Jaffe	ASC	230-3	(650) 604-6456

ARC 735 (Sep 97)E Previous editions are obsolete

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Wireless Video Measurements of Rotor Blade Displacement and Deformation

Investigator(s) (show affiliation)

Douglas Lillie, ARC; Alan J. Wadcock, AerospaceComputing Inc., ARC

Funding

Year Initiated FY97

Total prior to FY 98 $50,000

Total expended in FY 98 (Estimated)

In-house $50,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 98 $50,000

Requested for FY (If any)

Status of Study

☒ Completed in FY 98 ☐ Continued in FY

If continued in FY ☐ With funds remaining? ☐ With FY funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To demonstrate a portable system for the measurement of rotor blade displacement and deformations. Portability of the system is used to describe the self-contained nature of the proposed system, which requires zero slip ring channels for either signal transmission or power supply.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

Refine the system to the point where it can be used in a wind tunnel test.

Prepared by	Org. Code	M/S	Phone
Alan Wadcock	ARA	T12-B	(650) 604-4573

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Validation of a Nose-Channel Concept for Supersonic Drag Reduction

Investigator(s) (show affiliation)

Mark E. Newfield, ARC; Stephen M. Ruffin, Georgia Institute of Tech.

Funding

Year Initiated FY97

Total prior to FY 98 $40,000

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 98 $40,000

Requested for FY 99 0 (If any)

Status of Study

☒ Completed in FY 98 ☐ Continued in FY

If continued in FY ☐ With funds remaining? ☐ With FY funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To conduct an experimental proof-of-concept study to validate the computationally predicted drag reduction at supersonic speeds for a body with a hollow channel extending from the nose to the trailing edge. This objective is being accomplished by measuring the lift and drag of axisymmetric channel and baseline solid sphere/cone models flying in the Ames Ballistic Range.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Newfield, Mark E.: Validation of a Nose-Channel Concept for Supersonic Drag Reduction. AIAA Paper 99-0897, presented at the 37th Aerospace Sciences Meeting, Reno, Nev., Jan. 11–14, 1999.

Planned future work

If funded, the next phases of the investigation will focus on expanding the test envelope to M = 8 and evaluating the use of channel technology for vehicle directional control.

Prepared by	Org. Code	M/S	Phone
Mark E. Newfield	ASA	230-2	(650) 604-4893

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Simulation Modeling Investigations of the Terrestrial Carbon Cycle

Investigator(s) (show affiliation)

Christopher Potter, ARC; Steven Klooster, Calif. State Univ., Monterey Bay; Vanessa Brooks, JCWS

Funding

Year Initiated FY97

Total prior to FY 98 $40,000

Total expended in FY 98 (Estimated)

In-house $5000

Contracts (identify) $35,000 (Cal State Coop)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 98 $40,000

Requested for FY 99 (If any) 0

Status of Study

☒ Completed in FY 98 ☐ Continued in FY

If continued in FY ☐ With funds remaining? ☐ With FY funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To enhance collaboration between NASA Ames scientists working in the disciplines of ecosystem science and information technology.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Potter, Christopher; and Brooks, Vanessa: Global Analysis of Empirical Relationships between Annual Climate and Seasonality of NDVI. Paper presented at the annual meeting of the Ecological Society of America in Albuquerque, New Mexico, Aug. 10–14, 1997. Also in press in Inter. J. Remote Sensing.

Potter, Christopher; and Klooster, Steven: Dynamic Global Vegetation Modeling for Prediction of Biogenic Trace Gas Fluxes. Paper presented at the International Geosphere-Biosphere Program GTCE-LUCC Science Conference in Barcelona, Spain, March 21, 1998. The paper has been submitted, by invitation of IGBP, to Global Ecology and Biogeography Letters.

Planned future work

The model framework will be used to merge historical satellite and climate records from thousands of locations across the globe to determine whether regional hydrology has changed significantly during the past decade of El Nino events in both managed agricultural and natural landscape areas.

Prepared by	Org. Code	M/S	Phone
Christopher Potter	SGE	242-4	(650) 604-6164

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Simulations of Mechano-Chemical Deposition and Etching of Atomic Nanostructures on Diamond and Silicon Surfaces

Investigator(s) (show affiliation)

Subhash Saini, ARC; Deepak Srivastava, MRJ, Inc., ARC; F. N. Dzegilenko, ARC; M. Menon, U. Kentucky

Funding

Year Initiated FY97

Total prior to FY 98 $25,000

Total expended in FY 98 (Estimated)

In-house $55,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 98 $55,000

Requested for FY (If any)

Status of Study

☒ Completed in FY 98 ☐ Continued in FY

If continued in FY ☐ With funds remaining? ☐ With FY funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To demonstrate the feasibility of mechanically driven chemical reactions on diamond and silicon surfaces, and study the effect of such chemical pathways on the nanoscale atomic deposition and etching on technologically important silicon and diamond surfaces. Specifically, investigate the carbon nanotube-based scanning probe microscopic tip assisted atomic deposition and etching on solid surfaces.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Srivastava, D.; and Barnard, S. T.: Molecular Dynamics Simulation of Large Scale Carbon Nanotubes on a Shared Memory Architecture. IEEE, Proc. Super Computing 97, 1997.

Dzegilenko, F.; Srivastava, D.; and Saini, S.: Simulations of Carbon Nanotube Tip Assisted Mechano-Chemical Reactions on a Diamond Surface. Nanotechnology, vol. 9, no. 4, Dec. 1998, pp. 325–330.

Dzegilenko, F.; Srivastava, D.; and Saini, S.: Nanoscale Etching and Indentation of Silicon(001) Surface with Carbon Nanotube Tips. Phys. Rev. Lett., submitted 1998.

Srivastava, D.; Dzegilenko, F.; Barnard, S.; Saini, S.; Menon, M.; and Weeratunga, S.: Carbon Nanotube Based Nanotechnology in an Integrated Modeling and Simulation Environment. In a Handbook on Nano-technology, published by Academic press, 1998.

Planned future work

Simulations have demonstrated the feasibility of nanoscale indentation and etching of silicon survaces with carbon nanotube tips. The results will be communicated to the nanolithography community for experimental verification and demonstration. Larger simulations with multiwall, and ropes of nanotubes will be attempted to test the feasibility of mechano-chemical nanolithography of silicon survaces. The future work will be carried out under Nanotechnology (ITMS group at NAS currently funded by IT program at NAS).

Prepared by	Org. Code	M/S	Phone
Deepak Srivastava	IN	T27A-1	(650) 604-3486

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

The Origin and Control of 3-D Phenomena in Nominally 2-D Flows

Investigator(s) (show affiliation)

Murray Tobak, ARC; Jonathan H. Watmuff, MCAT Inst., ARC

Funding

Year Initiated FY96

Total prior to FY 98 $40,000

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 98 $40,000

Requested for FY (If any)

Status of Study

☒ Completed in FY 98 ☐ Continued in FY

If continued in FY ☐ With funds remaining? ☐ With FY funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To investigate the physical processes leading to the formation of streamwise vortices downstream of a nominally two-dimensional (2-D) attachment-line flow.
To explore the role of local pressure gradient as a parameter for controlling the subsequent development of the vortices.
To explore the stability characteristics of the streamwise vortices.
To explore conditions under which interactions between the vortices and other disturbances are favorable or adverse.
To develop more sophisticated methods for quantifying wind tunnel flow quality.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

Investigate origin of 3-D phenomena in 2-D separation bubble on flat plate and axisymmetric separation bubble on hemisphere/cylinder model (funding from IITS).

Prepared by	Org. Code	M/S	Phone
J. H. Watmuff/M. Tobak	AIP	260-1	(650) 604-5855

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Super Low Thermal Conductivity and Low-Density Ablative Composites

Investigator(s) (show affiliation)

Huy Tran and Christine Johnson, ARC

Funding

Year Initiated FY96

Total prior to FY 98 $40,000

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/98

Authorized in FY 98 $40,000

Requested for FY (If any)

Status of Study

☒ Completed in FY 98 ☐ Continued in FY

If continued in FY ☐ With funds remaining? ☐ With FY funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To demonstrate the feasibility of chemically combining aerogel technology with the latest light-weight ceramic ablator material to produce an ultralow thermal conductive in-depth material with high ablative performance at the outer surface. This objective is being accomplished by integrating the aerogel material for its super insulative properties and different light ceramic ablators material for their ablative characteristics.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

Prepared by	Org. Code	M/S	Phone
Huy Tran	STM	234-1	(650) 604-0219

ARC 735 (Sep 97)E Previous editions are obsolete

Appendix A-2
Ongoing Reports

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Gas-Phase Spectroscopy of Interstellar PAH Analogs

Investigator(s) (show affiliation)

Lou Allamandola, ARC; Farid Salama, SETI, ARC; Anthony O'Keefe and Jim Scherer, LGR; Richard Saykally, UC Berkeley

Funding

Year Initiated FY97

Total prior to FY 98 $50,000

Total expended in FY 98 (Estimated)

In-house $36,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/99

Authorized in FY 98 $36,000

Requested for FY 99 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☐ With funds remaining? ☒ With FY 99 funds?

If transitioned to other funding, to RTOP (number?) 344-01-57-41

to Program (name?) UV, Visible and Gravitational Astrophysics (UVGA)

to Other (identify)

Purpose of investigation

To investigate the potential interrelationship between interstellar polycyclic aromatic hydrocarbons (PAHs) and the carriers of the diffuse interstellar bands (DIBs). The goal is to measure, for the first time, the gas-phase spectra of selected neutral and ionized interstellar PAH analogs to allow a decisive test for these species as potential DIB carriers. These goals can be achieved by using the combined techniques of supersonic free-jet expansion spectroscopy (JES) and cavity ring down absorption spectroscopy (CRDAS).

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The feasibility study of the coupling of the supersonic jet expansion chamber with a cavity ring down chamber has resulted in the first measurement of the electronic spectrum of a PAH cation in the gas phase. The results obtained so far are a real breakthrough in astrophysics as well as in molecular spectroscopy and are reported in an article submitted for publication in Physical Review Letters.

Planned future work

The JES-CRDAS system will be set up in the Ames Astrochemistry Laboratory to measure the gas-phase electronic spectra of a representative set of PAH ions. The new experimental facility that will result from this project will provide the Ames Astrochemistry Laboratory with a unique research tool to mimic the interstellar environments and to generate data that can be compared directly with astronomical spectra.

Prepared by	Org. Code	M/S	Phone
Farid Salama	SSA	245-6	(650) 604-3384

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Development of a Tethered-Glider Probe-Positioning System for Use in Wind Tunnel Testing

Investigator(s) (show affiliation)

Dale L. Ashby, ARC; Hiroyuki Kumagai, AerospaceComputing, Inc. (ACI)

Funding

Year Initiated FY97

Total prior to FY 98 $40,000

Total expended in FY 98 (Estimated)

In-house $16,000

Contracts (identify) $17,000 RnR Composites

Grants (identify)

Expected completion date 9/30/99

Authorized in FY 98 $40,000

Requested for FY 99 (If any) 0

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☒ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To demonstrate the feasibility of using a tethered glider as a minimally intrusive probe-positioning system in a wind tunnel environment. The new probe-positioning system, if successful, would provide a cheaper, more flexible means of conducting flow surveys with probes such as hot wires or seven-hole probes in a large wind tunnel like the National Full-Scale Aerodynamics Complex (NFAC). The capabilities of an onboard miniature data-acquisition system and a flight-control system will also be demonstrated. If the tethered glider concept proves feasible, future enhancements to the system will include incorporating a propulsion system for increased positioning flexibility.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The fabrication of the first glider airframe has been completed. The composite construction of the glider allows additional glider airframes to be produced at low cost. The initial outdoor flight test of the glider was successfully completed. For the initial flight test, the data-acquisition and flight-control systems were not installed in the airframe and a conventional radio control was used to control the glider. Programming of the flight-control system and the probe-positioning and attitude-determination system is under way. A servointerface, which includes an emergency manual control override, has been developed, fabricated, and tested.

Planned future work

Planned work for FY99 includes installation of the miniature data-acquisition and flight-control systems, the solid-state gyroscopes, linear accelerometers, and batteries in the glider airframe. Several outdoor flight tests will be conducted using the onboard flight-control system to fly the glider. Programming the flight-control system and the probe-position and attitude-determination system will also be completed. The complete probe-positioning system will then be tested in the NFAC sometime in FY99, depending on tunnel schedule and availability.

Prepared by	Org. Code	M/S	Phone
Dale Ashby	AII	247-2	(650) 604-5047

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Where Are the Hidden Supernovae?

Investigator(s) (show affiliation)

Jesse Bregman, Diane Wooden, and Tom Roellig, ARC

Funding

Year Initiated FY98

Total prior to FY 98 None

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/99

Authorized in FY 98 $40,000

Requested for FY 99 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☐ With funds remaining? ☒ With FY 99 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To determine whether there are supernovae hidden from view at optical wavelengths in the cores of starburst galaxies and to measure how often they occur.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

None

Planned future work

The drive electronics will be tested with an existing engineering array and then the science array will be installed, tested in the lab, and taken to the telescope for performance measurements. Upon verification of performance, the system will be installed and used at the University of Wyoming telescope in late winter or early spring for initial galaxy observations.

Prepared by	Org. Code	M/S	Phone
Jesse Bregman	SSA	245-6	(650) 604-6136

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Graphics Software Architectures for True Three-Dimensional High-Resolution Volumetric Displays

Investigator(s) (show affiliation)

Steve Bryson, ARC; Chris Henze, MRJ, Inc., ARC

Funding

Year Initiated FY98

Total prior to FY 98 0

Total expended in FY 98 (Estimated)

In-house 0

Contracts (identify)

Grants (identify)

Expected completion date 9/30/99

Authorized in FY 98 $40,000

Requested for FY 99 0 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☒ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

Development of a simple graphics library that renders three-dimensional graphical primitives in volumetric displays using the "sparse rasterization," a new approach that combines raster and vector techniques. This library would be used to create three-dimensional graphics that can be viewed by many participants on a single display.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

Begin research as soon as the required hardware is delivered.

Prepared by	Org. Code	M/S	Phone
Steve Bryson	INA	T27A-1	(650) 604-4524

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Self-Contained Oculomotor Tracking System (SCOTS) to Study Gaze Control in Humans during Self-Locomotion

Investigator(s) (show affiliation)

Malcolm Cohen, ARC; Geoffrey Bush, LMSEC; Eric Sabelman, Dept. of Veterans Affairs Medical Center

Funding

Year Initiated FY98

Total prior to FY 98 0

Total expended in FY 98 (Estimated)

In-house $39,800

Contracts (identify)

Grants (identify)

Expected completion date 9/30/99

Authorized in FY 98 $40,000

Requested for FY 99 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☐ With funds remaining? ☒ With FY 99 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To develop a portable and compact system that can measure and record the movements of both eyes and the head while the subject is engaging in normal daily activities such as walking, running, standing up, and sitting down.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

Incorporate the Altera chip (under development at the VA Medical Center, Palo Alto, CA) and test response of the digital accelerometers. Develop program for automated real-time data acquisition.

Prepared by	Org. Code	M/S	Phone
Geoffrey Bush	SLR	242-3	(650) 604-1678

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Vestibular Galvanic Stimulation as a Countermeasure for Muscle Atrophy

Investigator(s) (show affiliation)

N. Daunton, ARC; I. Polyakov, San Jose State Univ. Foundation; M. Corcoran, ARC; R. Fox, San Jose State Univ.

Funding

Year Initiated FY97

Total prior to FY 98 $20, 000

Total expended in FY 98 (Estimated)

In-house $5000

Contracts (identify)

Grants (identify) $55,000 (NCC2-1022)

Expected completion date 5/30/99

Authorized in FY 98 $60,000

Requested for FY 99 0 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☒ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

Muscle atrophy during and following spaceflight is one of the most serious health problems facing the space program. No effective countermeasure exists. We believe that vestibular galvanic stimulation provides an innovative, potentially effective, and practical approach to this problem, yet it is virtually untested. If effective, it would have enormous benefits to the space program and also for the prevention of muscle atrophy in clinical situations. The overall objective of this research is to determine whether noninvasive vestibular galvanic stimulation will prevent or minimize muscle atrophy induced by unloading.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Polyakov, I. V.; Kaufman, G. D.; Daunton, N. G.; Fox, R. A.; and Perachio, A. A.:. The Effect of Galvanic Translabyrin-thine Utricular Stimulation on Fos Expression in the Gerbil Brain and Spinal Cord. Paper presented at 27th Annual Meeting of the Society for Neuroscience, New Orleans, La., Oct. 25–30, 1997; Society for Neuroscience Abstracts, vol. 23, 1997, p. 1291.

Daunton, N.; Fox, R.; Corcoran, M.; Taber, P.; and Wu, L.: Suppression of Otolith-Spinal Reflex by Chronic Hypergravity Exposure and Streptomycin Treatment. Paper presented at 27th Annual Meeting of the Society for Neuroscience, New Orleans, La., Oct. 25–30. 1997: Society for Neuroscience Abstracts. vol. 23. 1997. p. 754.

Planned future work

Electrode placements will be optimized and the effects of chronic vestibular galvanic stimulation on morphhology and electrical activity of hind-limb muscles in rats under normal and chronically unloaded conditions will be assessed.

Prepared by	Org. Code	M/S	Phone
Nancy Daunton/Igor Polyakov	SLR	261-3	(650) 604-4818

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Prospective Memory in Dynamic Environments

Investigator(s) (show affiliation)

Key Dismukes and Roger Remington, ARC; Maria Stone, NRC; Grant Young, NMSU

Funding

Year Initiated FY97

Total prior to FY ____ ____

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify) ____

Grants (identify) ____

Expected completion date 9/30/99

Authorized in FY 98 $40,000

Requested for FY ____ ____ (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☒ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?) ____

to Program (name?) ____

to Other (identify) ____

Purpose of investigation

To determine how prospective memory is affected by factors such as working memory load of the ongoing task, how long the intention must be held in memory, and environmental cues that may support retrieval of the intention. To compare results in the paradigm to those from previous studies. To determine whether the present results can be accounted for in terms of mechanisms already well-elucidated for attentional processes and retrospective memory retrieval.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

Delineate practical ways in which individuals can reduce their vulnerability to forgetting deferred intentions.

Prepared by	Org. Code	M/S	Phone
Key Dismukes	AF	262-4	(650) 604-0150

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Martian Fossils in the ALH84001 Meteorite: An Independent Assessment of the Evidence

Investigator(s) (show affiliation)

Jack D. Farmer and David Blake, ARC

Funding

Year Initiated FY97

Total prior to FY 98 $40,000

Total expended in FY 98 (Estimated)

In-house $21,000

Contracts (identify) $19,000 (SETI)

Grants (identify)

Expected completion date 10/31/99

Authorized in FY 98 $40,000

Requested for FY 99 0 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☐ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify) Startup funding at Arizona State University

Purpose of investigation

To reevaluate the biogenicity of microfossil-like features found in Martian meteorite ALH84001, based on detailed comparisons to terrestrial analogs of known origin.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

1) Detailed morphometric comparison of all experimental cultures using SEM will be completed. 2) Carbonate precipitation within microcosms containing live cultures will be induced in order to observe the mechanisms of fossilization at the nanometer scale. 3) Quantitative morphometric comparisons of terrestrial analog materials and putative microfossils in ALH84001 will be made. 4) An archive of results will be developed to identify reliable criteria for assessing biogenicity of microfossil-like structures in ancient rock materials. Results of culture work will be submitted for publication in the spring of 1999.

Prepared by	Org. Code	M/S	Phone
Jack D. Farmer	SSX	239-4	(650) 604-5748

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

A Technique and Strategy for Probing the Organic Signature of mm–cm Sized Cometary Debris during a Meteor Storm

Investigator(s) (show affiliation)

Mark Fonda, ARC; Peter Jenniskens, SETI Inst., ARC

Funding

Year Initiated FY98

Total prior to FY 98 0

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/99

Authorized in FY 98 $40,000

Requested for FY 99 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY ____ ☐ With funds remaining? ☒ With FY 99 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To detect molecular bands that trace the kinetic conditions in the meteor path and identify molecular products of meteor ablation and chemistry of biogenic elements accreted into the Earth's atmosphere.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

This instrument was applied during the November 1998 Leonid meteor return, when meteor rates were high. Further improvements are expected as a result of the November flight. Hardware improvements will be made to prepare the instrument for the November 1999 deployment, including an effort to automate the recording procedure, construct hardware that makes the system more easy to use, develop the tools for data reduction, and improve spectral resolution and sensitivity with longer focal length optics.

Prepared by	Org. Code	M/S	Phone
Peter Jenniskens	SSX	239-4	(650) 604-3086

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

A Modeling Approach to Global Land Surface Monitoring with Low-Resolution Satellite Imagery

Investigator(s) (show affiliation)

Christine A. Hlavka, ARC; Jennifer Dungan, Cal State, Monterey Bay, ARC; Gerry P. Livingston, UVT

Funding

Year Initiated FY 97

Total prior to FY 98 $30,000

Total expended in FY 98 (Estimated)

In-house $30,000

Contracts (identify)

Grants (identify)

Expected completion date 12/1/98

Authorized in FY 98 $30,000

Requested for FY (If any)

Status of Study

☐ Completed in FY ☒ Continued in FY 99

If continued in FY 99 ☒ With funds remaining? ☐ With FY funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To develop a new approach to computing accurate estimates of global extents of land use/land cover types with maps derived from satellite imagery. This objective is being accomplished by: 1) testing models of the size distribution of patches of specific cover types as mapped with imagery of relatively fine spatial resolution, and 2) developing numerical procedures for estimating total area of these cover types of low-resolution satellite imagery that incorporate models of size distribution and effects of pixelation.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Hlavka, C.A.: Statistical Models of Landscape Pattern and the Effects of Coarse Spatial Resolution on Estimation of Area with Satellite Imagery. In: Quantifying Spatial Uncertainty in Natural Resources: Theory and Applications for GIS and Remote Sensing, H.T. Mowrer and R.G. Congalton, eds., Ann Arbor Press, Chelsea, Michigan, in press, 1998.

"A Modeling Approach to Global Land Surface Monitoring with Low-Resolution Satellite Imagery." Poster presented at DDF Poster Session at Ames Research Center, Nov. 4, 1997, and at the American Geophysical Union fall meeting in San Franciso, Calif., Dec. 8, 1997.

"Fragmented Land Cover Types and Estimation of Area with Coarse Spatial Resolution Imagery." Presented at the Third International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences in Quebec City, Quebec, Canada, May 20, 1998.

Planned future work

Results of initial tests, using two of our example imagery-based maps, of numerical procedures for estimating area are promising. Further tests, using the remainder of our example imagery-based maps, will be conducted.

Prepared by	Org. Code	M/S	Phone
Christine A. Hlavka	SGE	242-4	(650) 604-3328

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Spectroscopic Studies of Mass-Selected Ions and the Evolution of Carbon-Bearing Molecules in the Galaxy

Investigator(s) (show affiliation)

Douglas M. Hudgins, Thomas M. Halasinski, and Robert Walker, ARC

Funding

Year Initiated FY98

Total prior to FY ____ ____

Total expended in FY 98 (Estimated)

In-house ____

Contracts (identify) $38,000 (PR#A53046D) ABB Extrel

Grants (identify) ____

Expected completion date 9/30/99

Authorized in FY 98 $40,000

Requested for FY 99 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☐ With funds remaining? ☒ With FY 99 funds?

If transitioned to other funding, to RTOP (number?) ____

to Program (name?) ____

to Other (identify) ____

Purpose of investigation

To greatly increase and diversify the inventory of PAH-related transient species that can be studied spectroscopically in the laboratory.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

If successful, this project will continue for the foreseeable future.

Prepared by	Org. Code	M/S	Phone
Douglas M. Hudgins	SSA	245-6	(650) 604-4216

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Application of Unsteady CFD and Sensorless Adaptive Control for the Development of a Long-Term LVAD

Investigator(s) (show affiliation)

Dochan Kwak, ARC; Cetin Kiris, MCAT Institute, ARC

Funding

Year Initiated FY97

Total prior to FY 98 $40,000

Total expended in FY 98 (Estimated)

In-house $18,000

Contracts (identify)

Grants (identify) $22,500 (MCAT Inst., ARC)

Expected completion date 10/31/98

Authorized in FY 98 $40,000

Requested for FY 99 (If any) 0

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☒ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To apply computational methods for developing a long-term or a permanent ventricular assist device (VAD) by implementing adaptive control in conjunction with numerical simulations of time-varying pulsatile flow.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Various inflow cannula designs have been analyzed using a representative pulsatile flow condition from the heart. The VAD itself has been developed and tested based on constant average blood flow rate. An unsteady solution procedure from inlet cannula to exit has been developed. A new computational grid was generated for the improved geometry. Flow through the new design was simulated for three heartbeat cycles. The current pulsitile flow analysis will help define the overall performance and will be a guide for an optimum implantation configuration. The computed results have been postprocessed in movie format. The combined experimental and computational results will be used in application to the FDA for human implantation. A U.S. patent application was filed on Dec. 13, 1996, entitled "Rotary Blood Pump" (Serial # 08/766,886).

Kiris, C.; Kwak, D.; and Benkowski, R.: Incompressible Navier–Stokes Calculations for the Development of a Left Ventricular Assist Device, Computers and Fluids, vol. 27, no. 5–6, 1998, pp. 709–719.

Planned future work

The next challenge is to integrate the sensorless adaptive control and the flow simulation procedure for the development of a long-term VAD.

Prepared by	Org. Code	M/S	Phone
Dochan Kwak	AIC	T27B-1	(650) 604-6743

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year

Title of Investigation

7 Kelvin Pulse Tube Cooler Using Rare Earth Regenerators

Investigator(s) (show affiliation)

Jeffrey M. Lee, Peter Kittel, and Pat Roach, ARC; Ali Kashani and Ben Helvensteijn, Atlas Scientific; Mike Guzinsky, Caelum

Funding

Year Initiated FY97

Total prior to FY 97 0

Total expended in FY 98 (Estimated)

In-house $20,000

Contracts (identify) CTC $2500; CFIC $10,000

Grants (identify) UCLA $7500

Expected completion date 11/30/98

Authorized in FY 98 $40,000

Requested for FY 99 0 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☒ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?) ____

to Program (name?) ____

to Other (identify) ____

Purpose of investigation

To investigate and demonstrate a 7 kelvin pulse tube cooler using rare earths as the regenerator material. Two regenerator designs will be examined. The first will be tested using erbium-3-nickel (Er3Ni) in the form of small-sized spheres (200-μm diameter) and the second will use neodymium (Nd) coiled plates. These materials possess relatively high heat capacity at low temperature. The increased heat capacity will lead to better performing pulse tube coolers.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

None at this time

Planned future work

Regenerators will be tested in a pulse tube cooler.

Prepared by	Org. Code	M/S	Phone
Jeffrey Lee	SFT	244-10	(650) 604-5693

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Development of a Fully Automatic Mini-Holographic Optical Instrument for Fast Separating and Detecting Amino Acids

Investigator(s) (show affiliation)

Narcinda Lerner, ARC; Jr-Lung Chen and Thomas Shen, SETI Institute, ARC

Funding

Year Initiated FY98

Total prior to FY ____ ____

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify) ____

Grants (identify) ____

Expected completion date 9/30/99

Authorized in FY 98 $40,000

Requested for FY 99 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☐ With funds remaining? ☒ With FY 99 funds?

If transitioned to other funding, to RTOP (number?) ____

to Program (name?) ____

to Other (identify) ____

Purpose of investigation

To develop molecular imprinted polymers with specific binding properties for underivatized amino acids, and, using designed polymers, to prepare affinity mini-columns, and finally, based upon these mini-columns, to assemble an instrument that will efficiently separate and detect free amino acids for returned samples from future planetary spacecraft missions.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

The established synthetic protocols will be used to prepare molecular imprinted polymers for common amino acids and also to develop polymers that will bind free amino acids collectively. Mini-columns will be further developed, prepared, and tested. Using prepared affinity mini-colomns and a well-established detector, a complete chromatographic will be assembled and tested for the efficiency of amino acid separation.

Prepared by	Org. Code	M/S	Phone
Narcinda Lerner/Jr-Lung Chen/Thomas Shen	SSX	239-12	(650) 604-1156

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Exploring Carbon Nanotubes for Future 1-nm Nanolithography

Investigator(s) (show affiliation)

Dan Machak, ARC; Jie Han, MRJ, Inc., ARC; Hongjie Dai, Stanford Univ.

Funding

Year Initiated FY98

Total prior to FY 98 0

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/1/99

Authorized in FY 98 $40,000

Requested for FY 99 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☐ With funds remaining? ☒ With FY 99 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To exploit mechanical and chemical properties of carbon nanotubes (CNT) for use in tools for nanolithography and semiconductor device fabrication and metrology. CNT probes for atomic force microscopy are used to etch hydrogenated silicon surfaces, creating a 10-mm-wide line of silicon dioxide. This nanolithography process has important applications in semiconductor fabrication.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Dai, H.; Franklin, N.; and Han, J.: Exploiting the Properties of Carbon Nanotubes for Nanolithography. Applied Physics Letters, vol. 73, no. 11, 1998, pp. 1508–1510.

Garg, A.; Han, J.; and Sinnott, S. B.: Interactions of Carbon-Nanotubule Proximal Probe Tips with Diamond and Graphene. Physical Review Letters, vol. 81, no. 11, 1998, pp. 2260–2263.

Planned future work

In FY98, the principle was demonstrated using a multiwall CNT probe (10-mm diameter). In FY99, work will focus on using single-wall CNT probes (1-mm diameter) for writing 1–2-mm-wide lines.

Prepared by	Org. Code	M/S	Phone
Jie Han	IN	T27A-1	(650) 604-4799

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Large-Scale Processing of Carbon Nanotubes

Investigator(s) (show affiliation)

Meyya Meyyappan, John Finn, K. R. Sridhar, and Jeanie Howard, ARC

Funding

Year Initiated FY98

Total prior to FY 98 0

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/99

Authorized in FY 98 $40,000

Requested for FY 99 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY ____ ☐ With funds remaining? ☒ With FY 99 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To develop a chemical vapor deposition process to grow carbon nanotubes (CNTs) for nanotechnology applications. CNT is a material with extraordinary mechanical and electrical properties.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

FY99 work will involve understanding of growth mechanisms, and effects of temperature, feed gas composition and flow rate, type of catalyst, and technique to deposit catalyst particles, and other system parameters or growth characteristics. When we understand these issues, then growth on patterned substrates can be investigated.

Prepared by	Org. Code	M/S	Phone
M. Meyyappan	ST	229-3	(650) 604-2616

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Modeling and Optimization of Ultrafast Semiconductor Quantum Well Devices

Investigator(s) (show affiliation)

Cun-Zheng Ning and Peter Goorjian, ARC; Jianzhong Li, Arizona State University, ARC

Funding

Year Initiated FY98

Total prior to FY 98 0

Total expended in FY 98 (Estimated)

In-house $5000

Contracts (identify) $35,000

Grants (identify) NC2-5267

Expected completion date 9/30/99

Authorized in FY 98 $40,000

Requested for FY 99 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☐ With funds remaining? ☒ With FY 99 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To study the modulation and switching speed limit of the optoelectronic devices based on quantum well structures. The objectives are 1) to identify effects of important mocroscopic processes and 2) to formulate a comprehensive model and develop the relevant computer code for designing and optimizing quantum structures for ultrafast modulation and switching.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Ning, C. Z.: Partial and Total Alpha Parameters in Semiconductor Optical Devices. Applied Phys. Letters, vol. 72, 1998, pp. 887–1889.

Ning, C. Z.: Temperature Induced Alpha Factor. Proceedings of SPIE, 1998, vol. 3283, pp. 406–410.

Ning, C. Z.; and Hughes, S.: THz Modulation of Semiconductor Lasers through Plasma Heating (to be published).

Planned future work

To extend the current model by self-consistently coupling the plasma temperature equation with the laser equations. Another extension will be the inclusion of a more detailed phonon-scattering model. This will allow a more accurate determination of the upper limit for the modulation speed. The possiblility of ultrashort pulse generation will also be explored with the model.

Prepared by	Org. Code	M/S	Phone
Cun-Zheng Ning	IN	T27A-1	(650) 604-3983

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Toward a Phylogeny of Biological Functions

Investigator(s) (show affiliation)

A. Pohorille and M. New, ARC; P. Cheeseman, Caelum; K. Schweighofer and M. Wilson, UCSF

Funding

Year Initiated FY98

Total prior to FY 98 0

Total expended in FY 98 (Estimated)

In-house

Contracts (identify)

Grants (identify) (NCC2-1038) $38,680

Expected completion date 9/30/99

Authorized in FY 98 $40,000

Requested for FY 99 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☐ With funds remaining? ☒ With FY 99 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To develop novel computational approaches, based on modern information theory, for incorporating sequence, structural, and functional information about a group of proteins into a single representation, and for using this representation to answer fundamental questions regarding the evolutionary relationships between proteins and their functions. These new methods will be first applied to the well-studied superfamily of ligand-gated ion channels. The evolutionary relationship, if any, between the ligand-gated ion channels and the voltage-gated ion channels will be determined.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

The most comprehensive sequence alignment to date of the superfamily of ligand-gated ion channels was constructed.

A three-dimensional model of the human glycine receptor, for which no high-resolution structural data exist, was constructed using the above alignment in concert with experimental constraints.

Planned future work

A new algorithm for jointly encoding sequence and structural information, based on the concept of self-dissimilarity, will be elaborated. Methods for phylogenetic tree construction using this new encoding will be developed.

Prepared by	Org. Code	M/S	Phone
Andrew Pohorille/Michael New/Karl Schweighofer	SSX	239-4	(415) 604-5759

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

DNA Damage Repair in Nature?

Investigator(s) (show affiliation)

L. Rothschild, ARC; N. Pearson, G. Moore, and K. Warren, SETI; J. Ashen, NRC; A. Buma and M. Velhuis, Netherlands

Funding

Year Initiated FY98

Total prior to FY 98 0

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 10/1/99

Authorized in FY 98 $40,000

Requested for FY 99 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☐ With funds remaining? ☒ With FY 99 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To determine if we are measuring DNA damage repair in nature. Much work has been conducted in other labs on the mechanisms and occurrence of damage repair, especially excision repair, in the laboratory setting, but it is unknown to what extent this phenomenon occurs in nature.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Rothschild, L. J.; and Pearson, N.: Application of Single Cell Gel Electrophoresis (Comet Assay) to Detection of DNA Damage in Protists. J. Phycol., vol. 34 (suppl.), no. 51, 1998.

Rothschild, Lynn J.: UV and Protistan Evolution. Paper presented at the International Soc. for Evolutionary Protistology, Flagstaff, Ariz., Aug. 1998.

Rothschild, Lynn J.: UV, Protists and Evolution. Paper presented at the BioForum, Calif. Academy of Sciences, San Francisco, Calif.. Oct. 1998.

Planned future work

Research has begun measuring excision repair in repair-deficient mutations of yeast and E. coli. Additional measurements have been made on phosphate uptake in nature. It is anticipated that work will be conducted using excision repair inhibitors on cyanobacteria and bouyant density gradients.

Prepared by	Org. Code	M/S	Phone
Lynn J. Rothschild	SGE	239-12	(650) 604-6525

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

New Insights into the Origin of Life: Dynamical Behavior of Networks and Cellular Automata

Investigator(s) (show affiliation)

Jeffrey D. Scargle, Shoudan Liang, and Silvano Colombano, ARC

Funding

Year Initiated FY98

Total prior to FY ____ ____

Total expended in FY 98 (Estimated)

In-house $36,000

Contracts (identify) ____

Grants (identify) ____

Expected completion date 11/30/99

Authorized in FY 98 $36,000

Requested for FY ____ ____ (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☒ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?) ____

to Program (name?) ____

to Other (identify) ____

Purpose of investigation

To understand the fundamental dynamical processes relevant to the origin of life and its subsequent evolution; to shed light on the formation of increasingly complex organic structures, and the subsequent development of living organisms. Also examined in detail is Stuart Kauffman's proposal that spontaneous generation of complexity—self-organization—may have operated in parallel with Darwinian evolution.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

1. Liang, S.; Fuhrman, S.; and Somogyi, R.: REVEAL, A General Reverse Engineering Algorithm for Inference of Genetic Network Architectures. Proceedings of the 1998 Pacific Symposium on Biocomputing, vol. 3, 1998, pp. 18–29.

2. Szallasi, Z.; and Liang, S.: Modeling the Normal and Neoplastic Cell Cycle with "Realistic Boolean Genetic Networks": Their Application for Understanding Carcinogenesis and Assessing Therapeutic Strategies. Proceedings of the 1998 Pacific Symposium on Biocomputing, vol. 3, 1998, pp. 66–76.

3. Scargle, J. D.: Studies in Astronomical Time Series Analysis. IV: Modeling Chaotic and Random Processes with Linear Filters. Astrophys. J., vol. 359, no. 2, 1990, pp. 469–482.

4. Scargle, J. D.: Studies in Astronomical Time Series Analysis. V. Bayesian Blocks, A New Method to Analyze Structure in Photon Counting Data. Astrophys. J., vol. 504, no. 1, 1998, pp. 405–418.

Planned future work

Work will be mainly in the area of genomic data analysis.

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Jeffrey D. Scargle	SST	245-3	(650) 604-6330

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Dexterous Walking for Mobility in Unstructured Terrain

Investigator(s) (show affiliation)

Michael Sims, David Wettergreen, Hans Thomas, ARC; John Bares, Dimitrious Apostolopolous, Carnegie Mellon University

Funding

Year Initiated FY97

Total prior to FY 98 $40,000

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/99

Authorized in FY 98 $40,000

Requested for FY 99 $40,000 (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY ____ ☐ With funds remaining? ☒ With FY 99 funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To develop gait planning and control for high-degree-of-freedom, walking robots with application to locomotion in unstructured, rough terrain. This effort is will develop new control techniques for dexterous walking and mobility, with an emphasis on behavior- and neural-based methods. In addition, these control techniques will allow the integration with reactive and deliberative control methodologies. To support development of these new algorithms, both a virtual environment simulator and a walking mechanism hardware testbed will be developed to demonstrate rough-terrain locomotion.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

Advanced gait-control algorithms will be developed and evaluated. In addition, the mechanical configuration being developed will be optimized around power consumption and maneuverability, key factors in the design of surface exploration systems.

Prepared by	Org. Code	M/S	Phone
Hans Thomas/Michael Sims	IC	269-3	(650) 604-5562

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

A Deployable Vortex Diffuser for Reducing Blade/Vortex Interaction Noise

Investigator(s) (show affiliation)

Chee Tung and Ken McAlister, ARC

Funding

Year Initiated FY97

Total prior to FY 98 $40,000

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/99

Authorized in FY 98 $40,000

Requested for FY ____ (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY ____ ☒ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To develop and test a new device on rotor blades that will reduce the blade/vortex interaction (BVI) noise during helicopter descent without compromising the desirable characteristics of the rotor at other flight conditions.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

A seven-foot model rotor test will be performed with a tip device that can be set to produce rapid trailing vortex dissipation from either secondary vortex pairing or severe turbulent diffusion. In-flight deployment concepts have been developed based on shape-memory alloy technology. Working models of these concepts will be produced.

Prepared by	Org. Code	M/S	Phone
Chee Tung/Ken McAlister	ARA	T12-B	(650) 604-5241

ARC 735 (Sep 97)E Previous editions are obsolete

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Adaptation to Virtual Gravitational Environments

Investigator(s) (show affiliation)

Robert B. Welch, Michael Aratow, Wanda Boda, Gene Korienek, and Robert Whalen, ARC

Funding

Year Initiated FY96

Total prior to FY 98 $20,500

Total expended in FY 98 (Estimated)

In-house $40,000

Contracts (identify)

Grants (identify)

Expected completion date 9/30/99

Authorized in FY 98 $40,000

Requested for FY ____ (If any)

Status of Study

☐ Completed in FY ____ ☒ Continued in FY 99

If continued in FY 99 ☒ With funds remaining? ☐ With FY ____ funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To create, test, modify, and ultimately perfect a treadmill-lower body positive pressure-virtual environment device designed to simulate the visual and kinesthetic/proprioceptive experience of walking in simulated altered gravity.
To measure the initial effects of these environments on balance and posture.
To induce and measure adaptation to this environment, as measured in terms of various characteristics of walking gait and walking accuracy.

FY____ applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Planned future work

Design a "preflight adaptation trainer" that might be carried aboard a spacecraft bound for Mars and used by astronauts to prepare for their arrival at new gravitational environments.

Prepared by	Org. Code	M/S	Phone
Robert B. Welch	SLR	239-11	(650) 604-5749

Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Assessment of Noise Exposure and Possible Resulting Hearing Loss in Commercial Aircraft Cockpits

Investigator(s) (show affiliation)

Elizabeth M. Wenzel, ARC; Durand R. Begault, San Jose State University Foundation

Funding

Year Initiated FY 97

Total prior to FY 98 $20,000

Total expended in FY 98 (Estimated)

In-house $18,000

Contracts (identify)

Grants (identify) NCC2-327 $42,000

Expected completion date 6/1/99

Authorized in FY 98 $60,000

Requested for FY (If any)

Status of Study

☐ Completed in FY ☒ Continued in FY 99

If continued in FY 99 ☒ With funds remaining? ☐ With FY funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To optimize auditory display design technology by characterizing the commercial aircraft acoustic environment and the hearing capacity of pilots through quantifiable measurements. This involves data collection of acoustic spectral data from commercial aircraft flight decks and audiogram data from pilots, and data analysis for a possible correlation between hearing loss and noise exposure.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Begault, D. R.; Wenzel, E. M.; Tran, L. L.; and Anderson, M. R.: Survey of Commercial Airline Pilot's Hearing Loss. Perceptual and Motor Skills, vol. 86, no. 1, 1998, p. 258.

Begault, D. R.: Virtual Acoustics, Aeronautics and Communications. J. Audio Engineering Soc., vol. 46, no. 6, 1998, pp. 520–530.

Planned future work

Further flight deck measurement data will be collected (one-third octave spectrum) during first quarter FY99, in coordination with availability of jump seat access. Noise dose data will also be gathered for individual pilots across a full duty day. Audiogram data will be collected in first and second quarter FY99 from 24 additional commercial pilots. Data analysis will be summarized in upcoming journal publication, along with engineering guidelines for adapting advanced acoustic avionics displays to personalized hearing sensitivity curves.

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Ames Research Center

DIRECTOR'S DISCRETIONARY FUND REPORT

Fiscal Year 1998

Title of Investigation

Constraining the Silicate Mineralogy in Comet Hale–Bopp: Discovery of Abundant Pristine Mg-Rich Pyroxene Crystals

Investigator(s) (show affiliation)

D. Wooden, ARC; C. Woodward and D. Harker, U. Wyo.; H. Butner, U. Az.; C. Koike, Kyoto Pharm. Univ.

Funding

Year Initiated FY 97

Total prior to FY 98 $17,000

Total expended in FY 98 (Estimated)

In-house $6500

Contracts (identify)

Grants (identify)

Expected completion date 11/30/98

Authorized in FY 98 $12,000

Requested for FY (If any)

Status of Study

☐ Completed in FY ☒ Continued in FY 99

If continued in FY 99 ☒ With funds remaining? ☐ With FY funds?

If transitioned to other funding, to RTOP (number?)

to Program (name?)

to Other (identify)

Purpose of investigation

To identify and quantify the silicate mineralogy of the submicron-sized grains in the inner coma of comet Hale–Bopp through analysis of HIFOGS spectroscopy of the 10-μm emission feature, taken over a large range of heliocentric distances (2.8 AU preperihelion, through perihelion at 0.93 AU, and out to 1.7 AU postperihelion). To test the hypothesis that Mg-rich crystalline pyroxene grains, only discovered when comet Hale–Bopp came close to the Sun, are cooler than the other silicate minerals because of their extreme Mg-richness. To investigate the possibility that these Mg-rich pryoxene crystals are interstellar relic stardust grains, and consider the implications on the delivery of interstellar organics to the early Earth by cometary bombardment.

FY 98 applications of results, patents, reports/publications, papers at meetings, any awards received, etc.

Wooden, D.H.; Harker, D.E.; Woodward, C.E.; Butner, H.M.; Koike, C.; Witteborn, F.C.; and McMurtry, C.W.: Paper submitted to Astrophs. J., 1998.

Wooden, D.H.; Harker, D.E.; Woodward, C.E.; Koike, C.; and Butner, H.M.: The Earth, Moon, and Planets. Proceedings of the 1st International Conference on Comet Hale–Bopp, Tenerife, Feb. 1998, in press.

Wooden, D.H.; Woodward, C.E.; Harker, D.E.; and Butner, H.M.: Paper presented at Protostars and Planets IV Meeting, Santa Barbara. Calif.. Julv 1998.

Planned future work

Advanced scattering computations of submicron grains to compute crystalline emission features, and the cometary emission spectrum over a size distribution of grains (with Th. Henning of Uni-Jena, Germany). Apply the same mineralogic analysis techniques to HIFOGS spectra of premain sequence Herbig Ae/Be stars to investigate the connection between crystalline silicates, cometary activity, and formation of protoplanetesimals in external star/planet forming systems (Proposal submitted to ROSS98 Origins NRA). Integrate Mie/multipole scattering computations into theoretical accretion disk models to compare theory with HIFOGS observations (to develop a more multidisciplinary approach to analysis with R. Bell and J. Cuzzi of ARC and B. Rodgers at U. Washington).

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13. ABSTRACT *(Maximum 200 words)*

This technical memorandum contains brief technical papers describing research and technology development programs sponsored by the Ames Research Center Director's Discretionary Fund during fiscal year 1998 (October 1997 through September 1998). Appendices provide administrative information for each of the sponsored research programs.

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